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[656 .222.4 (.493) & 656 .25 (.493)]

THE BELGIAN RAILWAYS.

Their present and future capacity,

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Figs. 1 to 3, pp. 901 to 908.

The question whether or not a through canal, to be used by boats of 1 350 tonnes, ought to be cut between Antwerp and Liége was raised before the Belgian « Commission on major Public Works ».

The Commission was asked in particular to reply to the following question :

« Whether the development of the rail-
« ways and of the new means for the bulk
« carriage of merchandise by rail, forms
« at least a partial solution of the prob-
« lem posed, namely : Means of providing
« for present and future traffic. »

As we were delegated to represent the National Company before the Commission, we were led to investigate the capabilities of the Belgian Railways from the triple aspect of :

traffic
cost prices
and rates.

As the problems technical, economic, and financial, placed before the Commission, especially affected the Eastern half of the country, our investigation was directed towards that section (1).

FIRST PART.

Traffic.

In 1913 the Belgian Railways carried 66 million tonnes (64 950 000 English tons) of heavy goods: in 1927 they carried 76 (74 800 000 English tons). The aver-

(1) We naturally looked into the capacity of the navigable waterways, but the results of this part of our investigation need not be given here.

age distance hauled per tonne of goods was 86 km. (52.59 miles per English ton) in 1913 : it rose to 103 km. (62.99 miles) in 1927, so that in this period the number of tonne-kilometres rose from 5 729 to 7 869 millions (from 3 503.7 to 4 812.4 million English ton-miles), that is, an increase of 37 %.

The number of trains, however, formed to carry this traffic fell from 787 000 in 1913 to 686 000 in 1927. If the average distance run by the trains increased from 45 to 46 km. (28 to 28.6 miles), the number of train-kilometres, 35 millions (21 748 000 train-miles) in 1913, none the less fell to 32 millions (19 884 000 train-miles) in 1927, which represents a reduction of 10 %.

This result is due to the increase in the *useful* load of the trains which rose from 173 to 277 t. (170.3 to 272.6 English tons) [1].

Briefly, the Belgian railways carried, in 1927, 37 % more tonne-kilometres than in 1913 with 10 % train-kilometres less. This at once gives an idea of the progress that can be effected in the operation of a railway !

If we take the Belgian lines and if along each line we draw bands of width in proportion to the number of goods trains moving over it each 24 hours we get a diagram giving a very suggestive idea of the density of traffic (fig. 1).

The width of the black bands shew that in spite of its unsatisfactory profile, the Luxembourg line (Arlon, Jemelle, Namur) is one of the most heavily loaded of the system. It deals with, on the most congested section, 8 to 9 million net tonnes of traffic both directions being added together [2], although the movement of goods trains is made difficult by the large number of passenger trains at different speeds run over it. The differences of speed between different trains over a line are an obstacle to intense operation, and consequently to the output of the line.

It will already be realised from the simple examination of the diagram what an extraordinary development of traffic is possible on the lines in the North East of Belgium which are located with easier gradients, some even on the level, and are not run over by passenger trains at high speed.

1. What is the present traffic on the railways in the Eastern section of the country ?

To answer this question, the diagram (fig. 2) has been prepared. This graph, *coloured in the original*, brings out very clearly the chief traffic currents in this area; we see especially :

— 1. Two heavy currents from the Grand Duchy of Luxemburg, from Alsace, from Lorraine and from the East of France towards Antwerp, one via Latour-Dinant-Ottignies, the other via Arlon-Jemelle-Namur-Ottignies. They amount together to 2 550 000 tonnes a year. In the opposite direction, 1 170 000 tonnes;

— 2. A current from Germany towards Antwerp via Montzen, of 720 000 tonnes a year. In the opposite direction, 480 000 tonnes;

— 3. Currents from the Liége district towards Antwerp by different routes, of 1 650 000 tonnes a year; in the opposite direction, 1 290 000 tonnes;

— 4. Currents from the Charleroi district towards Antwerp of 1 710 000 tonnes a year and 930 000 tonnes in the opposite direction;

— 5. Currents from the Campine in different directions : towards Liége

(1) Accessory carriage included.

(2) 50 trains $\times$ 2 $\times$ 300 days $\times$ 300 net tonnes.

Fig. 1.

Explanation of French terms (left bottom corner) :

OPERATING DEPARTMENT.

DIAGRAM No. 1

of the density of movement of goods trains.

EXPLANATIONS :

In the circle :
Number of trains entering daily.
Number of trains being marshalled. | Number of trains passing through.
Marshalling yards and converging stations.

Number of direct or semi-direct trains.
Number of local or stopping trains.
Double track lines.
Single track lines.
Companies lines.
Projected lines or lines under construction.

September 1926

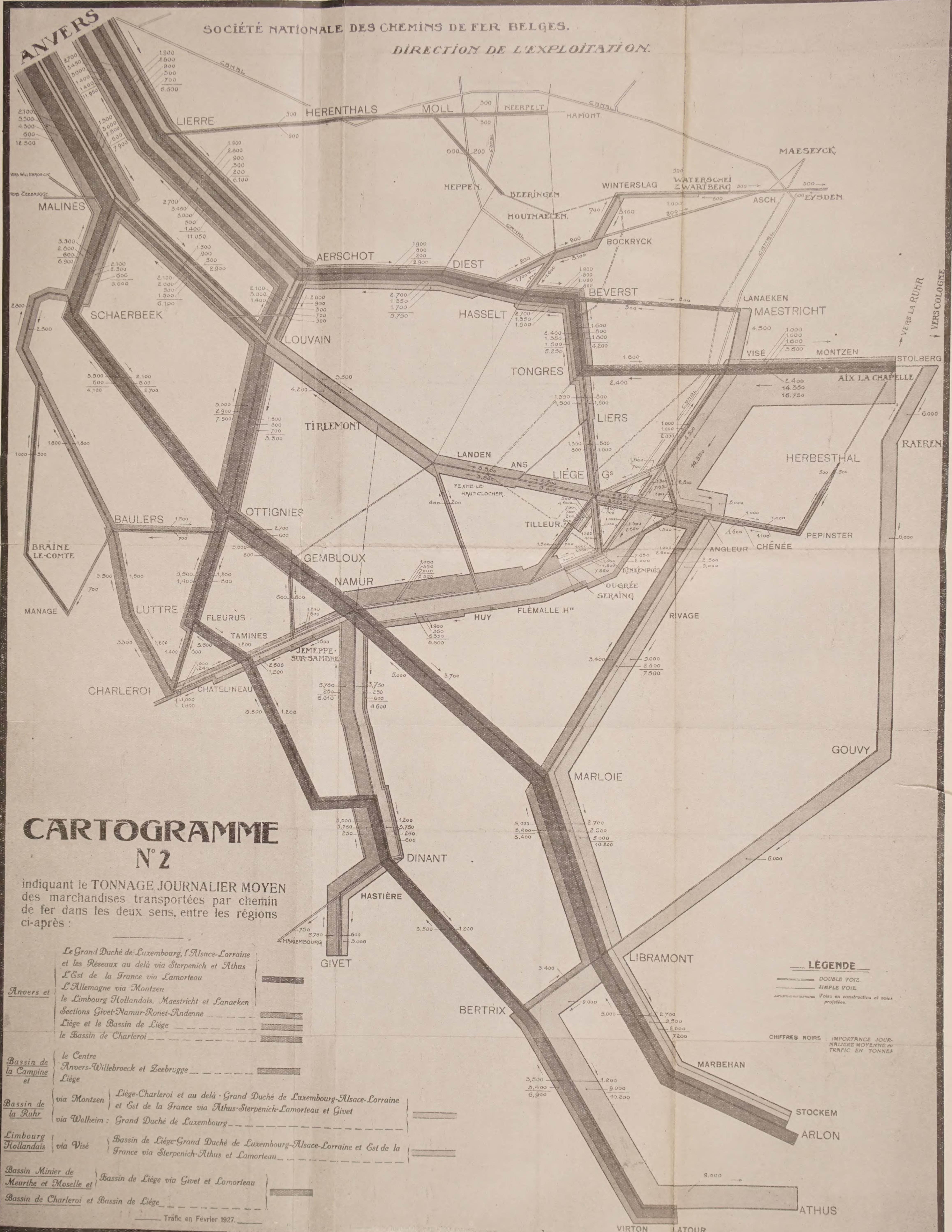


Fig. 2.

Explanation of French terms :

DIAGRAM No. 2

shewing the AVERAGE DAILY TONNAGE of goods carried by railway in both directions between the under-mentioned districts :

Antwerp and
- The Grand Duchy of Luxemburg, Alsace-Lorraine and the railways beyond via Sterpenich and Athus.
- The East of France via Lamorteau.
- Germany via Montzen.
- Dutch Limburg, Maestricht and Lanaeken.
- The sections Givet-Namur-Ronet-Andenne.
- Liége and the Liége district.
- The Charleroi district.

The Campine district
- The Centre.
- Antwerp-Willebroeck and Zeebrugge.
- Liége.

Ruhr district
- via Montzen: Liége-Charleroi and beyond ; Grand Duchy of Luxemburg-Alsace-Lorraine and Eastern France via Athus-Sterpenich-Lamorteau and Givet.
- via Walheim : Grand Duchy of Luxemburg.

Dutch Limburg — via Visé: Liége district-Grand Duchy of Luxemburg-Alsace-Lorraine and Eastern France via Sterpenich-Athus and Lamorteau.

Meurthe and Moselle districts and — Liége district via Givet and Lamorteau.

Charleroi district and — Liége district.

Right bottom corner : ═══ double track, — ——— single track, — ‗ ‗ ‗ ‗ Lines under construction or projected.
Black figures (in coloured diagram) = Average daily traffic in tonnes.

Traffic in February 1927.

540 000 tonnes a year; towards Antwerp 420 000 tonnes; towards Willebroeck and Zeebrugge, 150 000 tonnes, and towards the Centre, 210 000 tonnes;

— 6. Currents from the Ruhr district and from Aix-la-Chapelle via Montzen and via Walheim towards Luxemburg and Eastern France giving 3 300 000 tonnes a year; towards the Liége district and France via Jeumont, 2 805 000 tonnes a year;

— 7. Currents from Limbourg via Visé for Liége, 600 000 tonnes and for France by the Luxemburg line, 750 000 tonnes;

— 8. There are also currents originating in the Charleroi district for the Liége area of 372 000 tonnes. Currents from Meurthe et Moselle via Givet-Namur for Liége giving 1 725 000 tonnes. Currents from the same place and from Luxemburg towards Liége via Latour-Bertrix, giving 1 020 000 tons;

— 9. A current from the Maestricht district towards Antwerp, of 90 000 tonnes a year;

— 10. A current from the Namur district and the line from Namur to Givet towards Antwerp, of 180 000 tonnes.

Currents of the same order exist in the reverse direction.

These are the principal traffic movements noted on the lines in Eastern Belgium, and the volume of traffic is as shewn. The convergence of these traffics gives rise to a very heavy traffic in the neighbourhood of Antwerp. On the two lines from Malines and from Lierre to Antwerp we find a traffic of seven and a half million tonnes per annum towards Antwerp, and in the return direction of four and a half millions.

The whole of the figures that have been given refer solely to the main goods traffic, that is to say, passenger and pick up traffic have been excluded.

2 **What are the capacities of the Belgian railways without building any new lines ?**

The reply to this question is given in the diagram (fig. 3).

On the original the bands in three distinct colours shew :

a) The present annual traffic taken from diagram, (fig. 2), but to a scale one quarter that of figure 2;

b) The increase in the tonnage due to the present pick up traffic, and not shewn on the diagram of figure 2;

c) The tonnage that could be added to the present traffic by providing *additional trains* to the extent possible with the single and double lines in use, or on the point of being put into service, and this *with the loads being hauled at the present time over these lines.*

The fixed plant for handling the goods, etc., should be developed as the traffic grows; it is understood that the stations would receive as necessary the additional machinery found to be required.

We have allowed, based on experience with the Belgian system, that :

— on a single line, 24 trains can be worked daily in each direction; and

— on a double line, three times as many, that is, 72 trains each day in each direction.

These figures are minima. They can be exceeded on short sections on which there are neither water colums nor lay-by lines, such as those near large centres where the number of block sections has been multiplied. They take into account a loss of output of 4 hours out of

the 24 (a sixth) for maintenance and operating difficulties.

These figures have been confirmed by German authors : Doctor Giese, for example, fixes the respective numbers of trains as 24 and 80 for single and double track lines (1).

In addition, Mr. Javary, Director of Operating Services of the French Northern Railway, during the Meeting held in Lille on the 16 January 1921 on the work done by the Northern Railway during and after the War, stated that *before the War* it was generally agreed to be impracticable to run more than 72 trains in each direction on a double track line thoroughly well equipped for the purpose. Mr. Javary added that on certain days during the War the Northern Company ran *144*, thanks to the special character of the military trains and the complete exclusion of any public service.

As regards the tonnage per train (600, 700, 800 and 1 000 net tonnes, according to the lines) it was fixed on the basis of the hauling power at present available.

For goods to be carried in large quantities (coal, iron, ore), for goods from and to foreign railways, for those carried in special wagons, account ought to be taken of the return of the empty wagons to the loading points.

In addition, complete use of the power of the locomotives cannot also be assured (empty wagons, limit of the length of the trains).

In order not to exaggerate in any way, we have therefore considered that the goods trains would only carry in each direction *half* the useful loads given above.

These values are quite normal, and if anything, err by being on the low side.

(1) *Eisenbahn- oder Wasserstrassenförderung*, p. 19. — Publisher of the *Verkehrstechnik*, Berlin, 1927.

The following are a few valuable *conclusions :*

a) *with the present method of operation*, the double track Belgian lines can, without interfering with passenger and tranship traffic, carry the following annual tonnages, taking the two directions together :

10 millions on the Ans-Louvain line;
13 millions on the Beeringen-Moll line, and
18 millions on the Moll-Lierre line;

b) on the lines round about the Campine, the maximum capacity is far from having been reached;

c) the communications between Antwerp and Liége can be covered by several routes of great capacity.

In short, under the *present* conditions of the system, the transportation capacity of the Belgian Railways can be increased in very large proportions.

3. What will be the capacity for future traffic of the Belgian railways, taking into account the possible operating improvements, the works being carried out, and the new lines projected ?

Diagram (fig. 3) shows the *supplementary* tonnage that the railway would be able to carry :

a) by increasing the useful loading of the goods trains on the most important lines of the regions considered :

— to 1 500 tonnes instead of 1 000;
— to 1 000 tonnes instead of 600, 700 or 800;

b) by doubling certain of the present single track lines;

c) by allowing for à 20 % increase in capacity of the Stockem to Schaerbeek

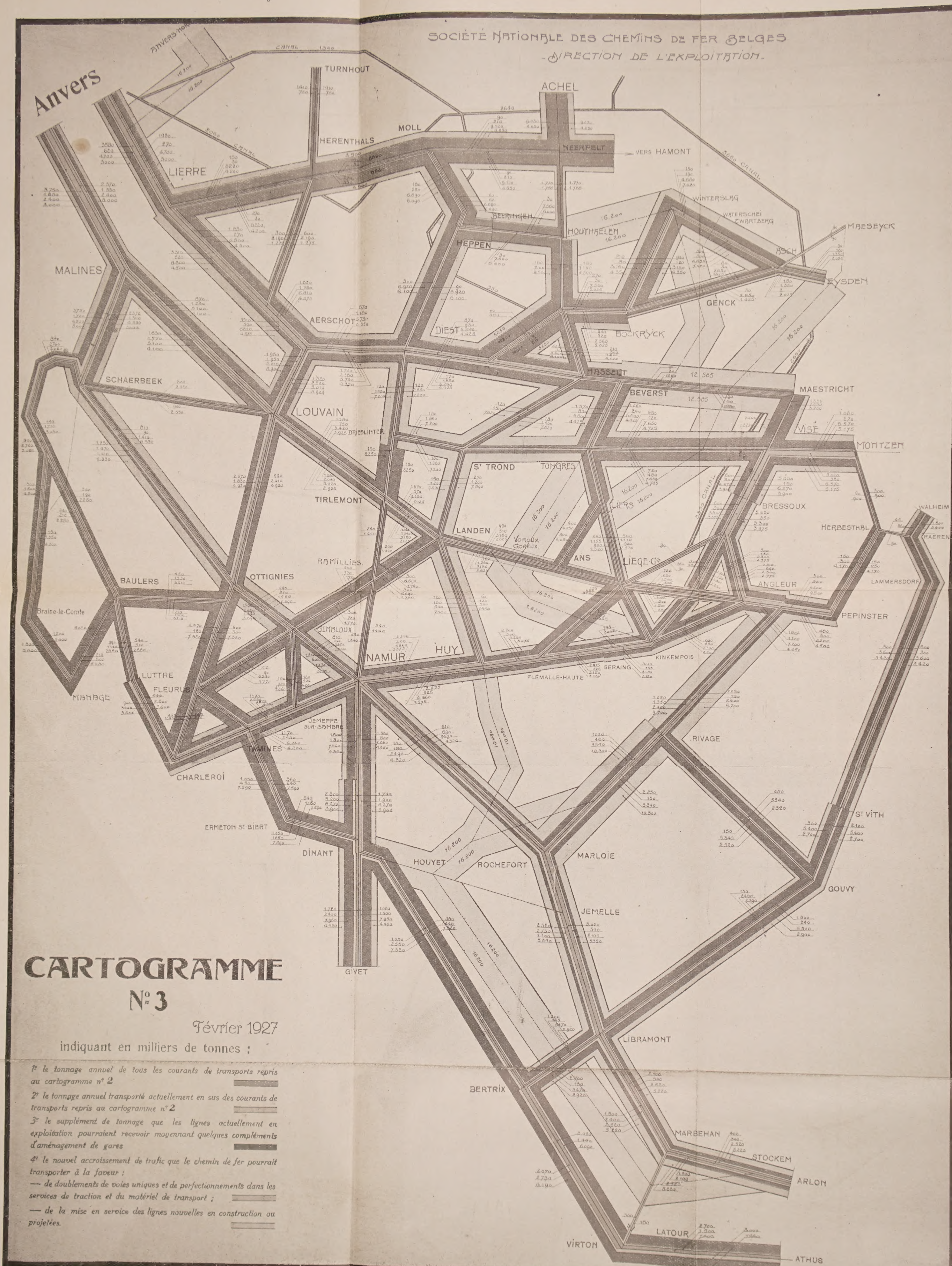


Fig. 3.

DIAGRAM No. 3

February 1927

indicating in thousands of tonnes :

1, the annual tonnage of the whole of the traffic currents taken from diagram No. 2;

Explanation of French terms :

2, the annual traffic carried at the present time over and above the traffic currents taken from diagram No. 2;

3, the additional tonnage the lines at present in operation could carry if certain additional equipment were provided in the stations;

4, the further increase in traffic the railway would be able to carry as a result of :
- doubling single track lines, improvements in the locomotive running services and in the rolling stock;
- putting into service new lines under construction or proposed.

line, and of the Marloie to Liége line as a result of electrification, and of the fitting of continuous brakes to the goods vehicles;

d) by counting upon the lines the construction of which is in hand, agreed, or under consideration, being available for service.

As regards the operation of the railway, progress can be very rapid. As an example, we have in 1927 increased from 600 to 900 tonnes the useful load of the ore trains over the line from Latour to Bertrix towards the Charleroi district, of the trains carrying manufactured steel from Latour in the direction of Antwerp, as of the trains from Lamorteau towards the Liége district : the load of these last has just recently been further increased from 900 to 1 120 tonnes of useful load.

Trains of 1 500 tonnes of useful load are therefore within the bounds of possibility in the near future. The Reichsbahn has put into service wagons of 19 tonnes tare to carry 60 tonnes of goods. Twenty-five such wagons can carry 1 500 tonnes of goods, and the gross weight of the train will be 2 000 tonnes. Now we have locomotives able to haul this load single headed over the easier lines.

Electrification makes it possible to increase the speeds up gradients : the speed of goods trains can be brought nearer that of stopping passenger trains, and the lay-by sidings are less used : there are no water columns; and the electric locomotives need be changed less frequently than in the case of steam locomotives.

All these points will undoubtedly result in increasing the output of the lines.

The use of the continuous brake on goods wagons will lead to the same results.

Taking all these circumstances into account, the traffic capacity revealed by the diagram (fig. 3) can be taken as being the following :

— for the Beeringen - Moll - Antwerp line, 13 million tonnes per annum in one direction only;

— for the line Genck-Langerloo-Tongres-Fexhe-le-Haut-Clocher - Kinkempois-Bassin de Liége, 12 million tonnes.

It may be recalled here that each of the pits in the Campine coal field is equipped to draw 4 000 to 5 000 tonnes a day, which means 1 200 000 to 1 500 000 tonnes a year. The Genck-Liége line alone would therefore regularly deal with the total production of 8 or 10 pits.

We will therefore conclude that for a very long period the traffic capacity of the Belgian Railways is practically unlimited. The power of the locomotives, the capacity of the wagons, and the number of axles per train can be increased as required.

In neighbouring countries trains are made up of 150 or 160 axles instead of 120. In America wagons of 80 to 120 tonnes capacity are used for bulk traffic.

Three or four tracks can be laid in place of two, etc.

In addition, the National Railway Company has drawn up special rates for the carriage of large quantities which latter help in the formation of heavy and full trains running without re-marshalling from the station of origin to destination, that is to say, at a reduced cost.

PART TWO.

Working costs.

In *industrial* undertakings the *total cost price* of a manufactured product is made up of two parts :

1. The proportion of overhead financial charges (interest, sinking fund, general charges) carried;
2. The production costs which fall on it and which we may call direct charges.

To reduce the total cost price, it is necessary to produce large quantities : the permanent financial charges and the constant part of the general charges weigh less and less on each unit made, and the total cost approaches more nearly the partial cost price given by the direct production charges.

This is the well known effect of the « law of the use of mass quantities ».

In railway transport the same thing occurs. To get a low cost so as to be able to reduce the rates, it is essential to be able to count on plenty of traffic and the *traffic in bulk* is that which can be carried at the lowest rates.

We may repeat the three hypotheses we have considered in turn :

1. the present traffic;
2. additional traffic possible under present conditions;
3. the possible traffic after the lines and equipment have been extended.

We will now consider under each of these hypotheses the effect on the costs.

First hypothesis : **Present traffic.**

The average cost per tonne-kilometre has been 0.15 fr. for the fourth quarter of 1926 : it is slightly higher for 1927, but here the absolute value of the figures must not be considered, but their relative values.

1. *Total cost price.*

With a view to the calculation of the average cost price of carrying bulk traffic, we took eight principal currents of traffic of heavy goods, and the cost prices have been calculated in both directions by taking into account the characteristics of existing trains (method of haulage, gross train load allowed, useful load, make-up of the train as regards stock, probable return load). The traffic movements isolated in this way represent 61 % of the total traffic on the lines considered : that is, 13 million tonnes-kilometres daily out of 21 millions.

From table I below, the total expenditure on the 13 million tonne-kilometres of heavy goods carried daily is seen to amount to 1 465 000 francs or 11.15 c. per tonne-kilometre.

This cost price of 11.15 c. only represents 74 % of the average cost price of the system (15 centimes). This fact is explainable by the better utilisation of the stock and the longer haul of the goods trains considered.

This total cost price of 11.15 centimes is made up as follows :

Direct charges	5.30 c.
Indirect charges	3.90 c.
Capital charges	1.95 c.
	11.15 c.

The respective proportions of these elements in the cost price of carrying a

TABLE I.

TRAFFIC CURRENTS.	Tonne-kilometres, per day.	Average cost price per tonne-kilometre, in centimes.	Present daily expenditure : Total, in francs.	Direct charges, in francs.	Indirect charges, in francs.	Capital charges, in francs.
I	1 125 500	10.25	423 155	200 520	148 454	74 181
II	217 900	10.66	23 230	11 004	8 150	4 076
III	1 580 200	8.00	131 050	62 090	46 015	22 945
IV	1 021 000	11.77	120 160	56 870	42 168	21 122
V	741 800	9.01	67 580	32 038	23 722	11 820
VI	4 180 500	13.56	568 980	268 236	199 398	99 346
VII	487 900	14.00	68 310	35 424	21 958	10 928
VIII	796 000	8.13	64 710	30 645	22 685	11 380
Total	13 150 800	...	1 465 175	696 827	512 550	255 798
Cost per tonne-kilometre :		11.15 c.	=	5.30 c. +	3.90 c. +	1.95 c.

TABLE II.

TRAFFIC CURRENTS.	Tonne-kilometres, per day.	Partial average cost price per tonne-kilometre, in centimes.	Total cost, in francs.	Direct, charges, in francs.	Indirect charges, in francs.	Capital charges, in francs.
I	7 103 400	5.95	422 810	314 020	46 060	62 730
II	487 300	6.23	30 250	22 400	3 270	4 580
III	2 003 500	4.88	97 970	74 510	11 190	12 270
IV	1 442 500	6.27	90 450	69 800	10 550	10 100
V	6 464 700	4.54	293 300	222 250	33 220	37 830
VI	5 249 550	5.37	281 740	207 090	31 030	43 620
VII	794 600	5.03	39 970	30 990	4 610	4 370
VIII	1 164 500	3.86	44 950	34 470	5 240	5 240
Total	24 710 050	...	1 301 440	975 530	145 170	180 740
Cost per tonne-kilometre :		5.26 c.	=	3.94 c. +	0.59 c. +	0.73 c.

tonne-kilometre is therefore 48 %, 35 % and 17 %.

The direct charges include expenditure on fuel, oil, enginemen's wages, maintenance and repair of locomotives and rolling stock.

The indirect charges include the general expenses of administration and supervision, of management, workshops and stations, as well as the cost of maintenance of the track.

The financial or capital charges include the cost of industrial amortization, payments to renewal accounts, etc.

2. *Partial cost price or additional cost price per tonne.*

This is a question of the cost price obtained by abstracting the costs which continue to be incurred whether the traffic moves or not.

Each time the traffic can be increased without investing new capital for the equipment of the line or the purchase of locomotives or rolling stock, it is quite permissible not to take into account the capital charges already paid by existing traffic, and even to neglect that part of the general charges that will not increase at the same time as the traffic. It may be said in passing, that it is stupid self-deception to call cost prices so calculated « dumping » prices.

If we had to consider the minimum cost per kilometre per additional tonne for the carriage of coal, ore, iron, etc., forming the eight traffic movements considered, the indirect charges and the capital charges would be left out of count. The cost price per tonne-kilometre got out in this way would be only 5.30 centimes (the absolute minimum cost) which is only 35 % of the average cost price of the system (15 centimes).

SECOND HYPOTHESIS : **Possible traffic under the present condition of the lines.**

1. *Total cost price.*

The possible increase in the traffic under the « *present* » condition of the lines may be figured at 31 million tonne-kilometres per day over and above the present 21 millions.

The result is that the possible daily total traffic is 52 million tonne-kilometres :

a) Let us first of all calculate the average cost price of this additional tonnage (31 millions) considered separately; let us agree that this traffic will be composed entirely of *bulk* traffic, of which 24 millions will be distributed over the eight traffic currents previously considered, as shewn in table II.

In order to determine the total cost, we have, as in the previous case, considered some of the trains following these eight principal currents. To each train we have charged :

1. The total amount of direct charges attributable thereto;

2. Part of the indirect charges, considering the general charges for management, supervision, etc., remain the same;

3. The interest and amortization of the new rolling stock required (locomotives and wagons).

The average cost price per tonne-kilometre of *supplementary* traffic is no more than 5.26 centimes, whereas the cost of the present traffic is 11.15 centimes. The first only represents 47 % of the second;

b) Let us calculate the average cost price of the present traffic (21 million tonne-kilometres) *increased* by the possible traffic considered (31 million-tonne-kilometres) that is to say, of the traffic of 52 million tonne-kilometres.

TABLE III.

—	Tonne-kilometres, in millions.	Average cost price, in centimes.	Total expenditure, in millions of francs.
Present traffic	21 ×	11.15 =	2 397
Supplementary possible traffic	31 ×	5.26 =	1 635
Total possible traffic	52	7.67	4 032

TABLE IV.

—	Tonne-kilometres, in millions.	Direct charges per tonne-kilometre, in centimes.	Total direct charges, in millions of francs.
Present traffic	21 ×	5.30 =	1 139
Possible supplementary traffic	31 ×	3.94 =	1 225
Total traffic	52	4.49	2 364

The total cost is 4 032 millions for 52 million tonne-kilometres, whence a cost price of 7.67 centimes.

The average cost price per tonne-kilometre would therefore fall from 11.15 to 7.67 centimes, that is to say, it would only represent 51 % of the average cost price on the system (15 centimes) thanks to a full use of existing equipment.

2. *Partial cost price* (present plus supplementary traffic). If in certain particular instances we were led to consider the minimum minimorum kilometric cost of the supplementary tonnage, we should only take into account the direct charges in calculating the total cost.

Under the second hypothesis the minimum minimorum cost price falls to 4.49 centimes per tonne-kilometre, as compared with 5.30 centimes in the first hypothesis, it being understood that in this second hypothesis we have taken the whole of this traffic of 52 million tonne-kilometres as being made up of bulk traffic.

THIRD HYPOTHESIS : **Possible traffic in the event of the lines and equipment being increased.**

Total cost price.

The additional number of tonne-kilometres that could be worked after strengthening up the available equipment amounts to 26 million tonne-kilometres per day (that is, over and above the 52 millions).

In the absence of any indication as re-

gards the kind of trains to be hauled, the composition of the trains, and the dates the new capital would be available, it is impossible to establish an absolutely precise cost price under the third hypothesis.

Let us agree it will not be higher than that of the additional traffic of the second hypothesis (or 5.26 centimes) increased by the rate corresponding to the new capital charges. The number of tonne-kilometres to take into account is 52 + 26 = 78 million tonne-kilometres per day.

Let us estimate the interest and amortization charges at 10 % of the new capital, the increase per tonne-kilometre is 0.65 centimes and the average total cost price rises to 5.26 + 0.65 = 5.91 centimes in place of 11.15 centimes, representing therefore only 40 % of the average cost price of the whole system (15 centimes).

THIRD PART.

Rates.

The cost prices control the rates in the sense that they fix the minimum limit.

In order to determine the costs of carriage the railway ought to or should charge in the future, let us again consider our hypotheses.

First hypothesis. — Present position, therefore present rates.

Second hypothesis. — It has been shewn that in their present state the lines considered can deal with a supplementary daily traffic of the order of 31 million tonne-kilometres per day.

If this additional traffic was considered separately, it could be carried at the price of 5.26 centimes without the rate falling below the cost price. But the reduction of rate should apply not only to the supplementary traffic but also to the traffic being handled.

Let us consider then the total traffic under the hypothesis that the lines considered are being operated to saturation point, that is to say, if the volume of the traffic was 21 + 31 = 52 million tonne-kilometres per day : under these conditions the actual traffic of 21 million tonne-kilometres would be carried at the price of 7.67 instead of 11.15 centimes.

There would result a saving of 11.15 — 7.67 = 3.48 centimes per tonne-kilometre, or an *annual* saving of the order of 220 million francs [1] which would allow a general reduction of 11 % *on the whole of the rates.*

Third hypothesis. — Reductions of rates the railway could grant if we allow for an increase in the capacity of the lines obtained by extending the lines and equipment.

The works in view under the third hypothesis would require an immobilisation of capital, the amortization and interest on which would amount to 0.65 centimes per tonne-kilometre, but would enable 78 million tonne-kilometres to be carried, whence a reduction of 11.15—5.91=5.24 centimes in the cost price per tonne-kilometre. This reduction would enable the railway to effect an economy of the order of 330 million francs corresponding *to a general reduction of 16 % on the whole of the rates.*

(1) 3.48 centimes × 21 millions of tonnes-kilometres × 300 days.

As can be seen, if we have *bulk* traffic, the railway can without « dumping », rates that is to say, without carrying goods at rates below the cost price, offer very low rates equal to if not lower than those of other methods of transportation.

CONCLUSIONS.

If we regard it from the point of view of the *traffic*, the capacity of the Belgian railways is practically unlimited. The line from Beeringen to Antwerp alone can carry annually towards Antwerp, that is to say, in a single direction, 13 million tonnes, *i. e.*, half the coal mined in Belgium. This is indeed reassuring for the railway future in the Campine. If we consider it from the point of view of the *cost price* of carriage, and from that of the *rates*, we can conclude that each time that for any reason any traffic is taken from the railway, the cost price of the railway will automatically rise, and result in an appreciable increase in rates.

In order to have very low rates, it is necessary to concentrate on to the railway as much traffic as possible. Thanks to carriage of traffic in bulk, the railways will be able to use high capacity wagons, thereby reducing the operating costs, making better use of this capacity and getting a quicker turn-round of the stock.

The greater the volume of traffic, the easier it is to form an economical organisation, and the easier to group the elements of the traffic into currents which enable complete train loads, running at high speed, to be worked from the point of origin to the destination without check, in other words, trains which will give the minimum cost price.

[62. (01 & 669 .1]

Central white stains in ingots rolled before complete solidification,

By Mr. VITEAUX.

Figs. 1 to 10, pp. 917 to 920.

(*Le Génie Civil.*)

In an article recently published in the *Génie Civil* (1), Mr. Pichard developed certain arguments on the phenomena accompanying the solidification of steel ingots, and in particular on the formation of the « white stain » in ingots that have been rolled before the steel had completely solidified. He considered that during cooling, a central zone D (fig. 1) of the ingot *which would have practically the same composition as the original metal* or would be slightly freer from impurities as a result of liquation, remained in surfusion : too early rolling would fix the whole of the metal in zone D accompanied by a separation of impurities from D towards the surrounding zone C.

This explanation is very different from the theories so far brought forward to explain the formation of the « white stain » and does not agree with the very definite results of experiments we carried out some months ago, to see if these theories were well founded : we think the question ought to be completely elucidated.

Mr. Pichard appears to have based his theory principally on the macrographic appearance of rails having this « white stain », without having taken into account sufficiently, the very special chemical composition of these rails. Now rails with the « white stain », or more generally the products obtained by premature rolling of the steel ingots (in steel works language, *young ingots*) show in addition to the « white stain » characteristic of their macrographic appearance, a very definite heterogeneous chemical composition : this heterogeneity shows itself not only by the content of impurities, such as sulphur and phosphorus, but, and this is a point of capital importance, by the *content of carbon.*

The macrograph (fig. 2) is a picture of the section of a bloom of 170 × 180 mm. (6 11/16 × 7 1/16 inches) intentionally rolled from a steel ingot before complete solidification : at the points marked A, B, C, etc. on the photograph, we took, using a 7 mm. (9/32 inch) drill, samples for analysis. The following table gives the results obtained.

Content in per cent of	Samples.											
	A	B	C	D	E	F	G	H	I	J	X	Y
C.	0.412	0.536	0.444	0.393	0.334	0.279	0.232	0.200	0.162	0.132	0.432	0.432
Mn. . . .	1.000	1.055	1.010	1.005	0.975	0.955	0.925	0.890	0.910	0.910	1.000	1.000
Ph. . . .	0.075	0.101	0.064	0.050	0.038	0.032	0.027	0.026	0.023	0.023	0.068	0.068
S.	0.038	0.073	0.027	0.021	0.013	0.012	0.012	0.011	0.009	0.009	0.039	0.041

(1) See the *Génie Civil* of the 11 February 1928, vol. XCII. No. 6, page 132 and the *Bulletin of the International Railway Congress*, September 1928, page 751.

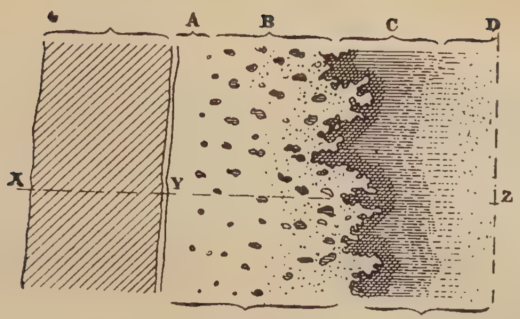


Fig. 1. — Part section of an ingot during solidification.

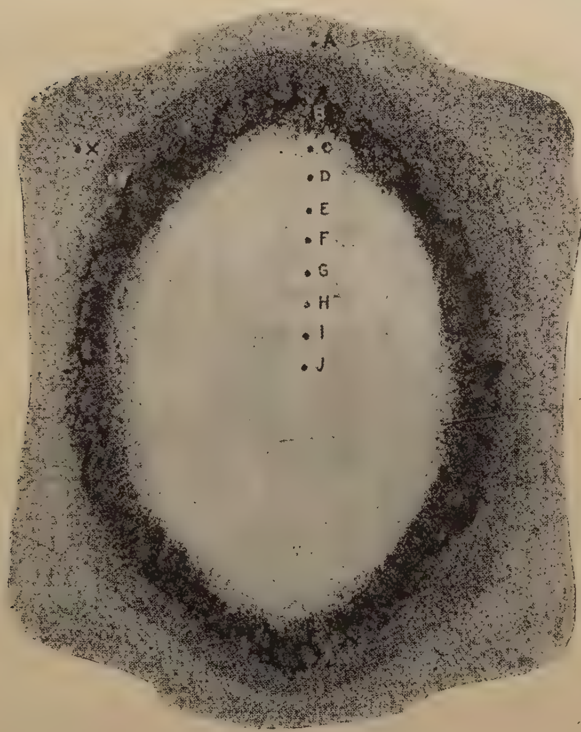
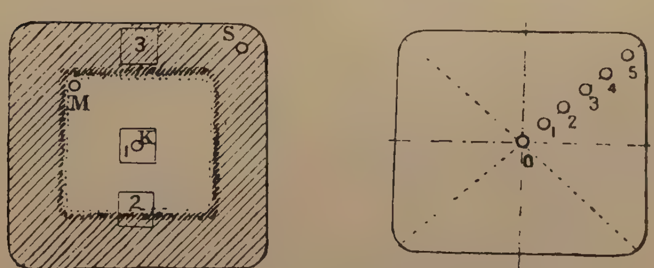


Fig. 2. — Bloom made from a rail steel ingot rolled before complete solidification.



Figs. 3 and 4. — Steel ingots tested by Mr. Karl Neu.

It will be seen that the metal in the white central area, and particularly that in the area H-I-J, completely differs in chemical composition from the steel as originally poured, and it would seem very difficult to admit that liquation only, followed by ã phenomen of surfusion, necessarily followed in turn by sudden solidification, could produce the considerable impoverishment in *carbon* phosphorus and sulphur, that an analysis reveals.

Mr. Karl Neu when director of the Neunkirchen Rolling Mills, appears to have been the first to point out the existence in ingots rolled before complete solidification of a central zone weaker in carbon, phosphorus and sulphur than the surrounding parts.

In *Stahl und Eisen* of the 7 March 1927, Mr. Neu gave particulars of many tests from mild steel and rail steel ingots : it will be sufficient if two sets ot test results be quoted :

1. **Analyses and mechanical characteristics of a mild steel ingot weighing 2 800 kgr. (6 170 lb.) rolled into 80 × 80 mm. (3 5/32 × 3 5/32 inches) billets after half an hour in the soaking pits** (fig. 3).

Tests marked	C	P	Mn	S	Tests.	Breaking strength.	Reduction of area.	Elongation on 100 mm. (3 15/16 inches).
	Per cent.	Per cent.	Per cent.	Per cent.		Kgr. per mm² (lb. per square inch).	Per cent.	Per cent.
S.	0.05	0.060	0.42	0.050	1.	34.5 (49 070)	60.8	36
M	0.10	0.105	0.46	0.120	2.	41.7 (59 300)	26.3	28
K	0.03	0.035	0.39	0.025	3.	35.4 (50 350	61.6	38

2. **Analyses from a rail steel ingot (2 tons) rolled into blooms after 15 minutes in the soaking pits** (fig. 4).

Tests.	C	P	Mn	S
	Per cent.	Per cent.	Per cent.	Per cent.
0	0.09	0.035	0.96	0.027
1	0.16	0.030	0.88	0.020
2	0.26	0.035	0.98	0.041
3	0.38	0.075	1.06	0.127
4	0.34	0.065	0.98	0.085
5	0.36	0.040	1.00	0.081

At the end of the article Mr. Neu endeavoured to explain the phenomenon by the compression action of the blooming mill rolls causing the liquid core to penetrate into the surrounding zones already solid, but still offering little resistance « in the way mercury penetrates a leather bag ». A point however remained without explanation « that is, the fact that in every case the core itself of the ingot always showed a reduced carbon content. However surprising and enigmatic this may be at the moment, it is however, an incontestable fact ».

It fell to Mr. E. Houbaer, Engineer of Messrs. Cockerill, to provide a logical

and complete explanation of this phenomenon. At the 1913 meeting of the « Iron and Steel Institute », Mr. B. Talbot proposed a method of producing sound steel by lateral compression. The process consisted in a slight drawing down of the ingot at the blooming mill before complete solidification in order to prevent piping. Mr. E. Houbaer investigated at Messrs.Cockerill's works at Liége, the possibilities of applying industrially the Talbot process, and reported the results of his tests in the *Revue universelle des Mines et de la Métallurgie* (March 1913). He pointed out the existence of the « white stain » in steel manufactured by the Talbot process : he referred to Mr. Neu's tests, and finally explained the phenomenon by linking it up with the well known laws governing the solidification of binary alloys. The theory of Mr. Houbaer may be summed up as follows.

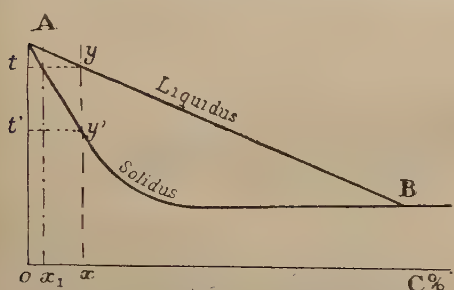


Fig. 5. — Diagram of a binary alloy.

Let us take (fig. 5) a steel of x carbon content when liquid : when during cooling down the steel falls to the temperature t, in the binary system Fe-C there will form crystals having a carbon content x_1, lower than x : at the same time the carbon content of the mother liquor will increase; the temperature continuing to fall, the quantity of crystals will steadily grow and their carbon content will gradually approach more nearly to x; the carbon content of the liquor will also increase in measure as the mass of the free liquid diminishes.

If we consider the binary system Fe-Ph analogous to the system Fe-C [1], it will also be seen that there will separate out from the liquid mass, after a certain temperature, crystals poorer in phosphorus than the mother liquor, etc. In the case of the sulphur which forms as a rule complex sulphates insoluble in the liquid steel, the position is different : certain globules of sulphates will be held by the crystals, but the major part will accumulate in the liquid.

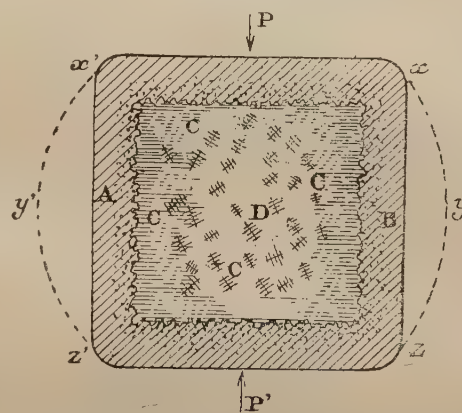


Fig. 6. — Cross section of an ingot during solidification.

Finally, an ingot in course of solidification can be likened to a box, the sides of which would be the parts that first solidified against the ingot mold. If we suppose the ingot to be laid down horizontally and we take a vertical section (fig. 6) through the middle of its length, this section will show a solid casing A, the interior of which consists of an open agglomeration of crystals intersected by intersticial spaces more or less full of pasty material B in process of solidifying, and at the centre a mass D of crys-

(1) See the paper published by the sub-committee of the Iron and Steel Institute : *On the homogeneity of steel ingots*, in the *Proceedings of the Iron and Steel Institute*, May 1926.

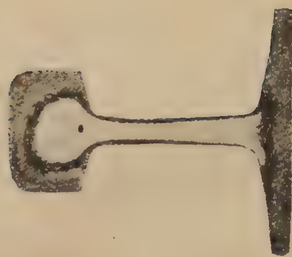


Fig. 10.
7th pass (finished rail).

Fig. 9.
3rd pass.

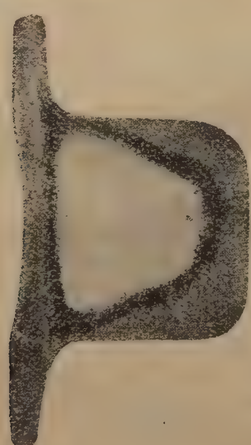


Fig. 8.
2nd pass.

Fig. 7.
1st pass.

Fig. 7 à 10. — Rolling of the bloom (fig. 2) into 36 kgr. (72-57 lb. per yard) standard rail of the principal French railway companies.

tals of low carbon, phosphorus and sulphur content plonged like a sponge into a liquid C rich on the contrary in these elements. The difference in composition between the crystals and the mother liquor will be furthermore the greater, as the temperature is higher, the purest crystals consequently being found at the centre of the box.

Let us now suppose the ingot be rolled down, the ingot being sufficiently set at the head and base for the steel, still liquid, not to run out at the ends. Under pressures at P and P′, the non malleable liquid or pasty mass C endeavours to escape in the perpendicular direction, that is to say laterally and enlarges the ingot at x, y, z, x', y', z' : it separates from the « sponge » like mass of crystals D as by a real squeezing, and collects between the solid walls A and the solid core D penetrating more or less deeply as Mr. Neu indicated, the rather open grained dendritic zone B, which primitively surrounded the zone A about C.

The result of this is the formation on the one hand, of the central white stain, and on the other, of the ring of impurities shown in the macrograph (fig. 2).

The phenomena are in reality more complex than those we have described. We are not dealing with isolated binary systems, but with a complex Fe-C-Ph-Mn-Si system; furthermore, the temperature continues to fall and solidification proceeds as the rolling is carried on; finally diffusion comes into action to a certain extent. A more complete description of these phenomena will be found in Mr. Houbaer's original note ; this resumé however, should be sufficient to give an idea of the effects produced.

If the solidified case A is not sufficiently thick when the ingot begins to swell out, this case breaks, either at various separate points, or even the full length of the generatrices y and y', sometimes accompanied by the liquid being driven out with great violence. It is

consequently advisable to observe considerable prudence when carrying out these tests.

As we have said above, we were led, during the past year, to investigate the formation of « white stain » in rails : we repeated the tests made by Messrs. Neu and Houbaer : we obtained results agreeing in every respect with theirs, and we believe that the theory put forward by Mr. Houbaer, explains in a very satisfactory manner the succession of the phenomena.

These tests of rolling « young » ingots have a direct value for metallurgists, as they make it possible to lay down with exactitude the conditions to be followed to avoid the formation of the « white stain ». From a more general point of view, they are also of very great value, because they make it possible in some degree, to stabilise and to seize upon as they occur certain transition phases of the solidification of steel ingots.

An illustration, such as figure 2 for example, completed by analysis from different points of the « white stain » shows the importance under certain conditions of cooling, delay in the diffusion in the crystals first formed, can assume.

When compared with the observations made by the Sub-Committee of the Iron and Steel Institute which enquired into the homogeneity of steel ingots, it makes it possible to understand more easily certain anomalies and certain heterogeneities pointed out by this Committee and which are experienced more particularly in the *case of large ingots for forging* (1).

The rolling of blooms showing the white stain, can, in addition, give valuable information on the work done during rolling (or forging), and about the deformation the metal undergoes at different parts of the section, during succeeding passes through the rolls, etc.

As an example, we give a series of macrographs (figs. 7 to 10) taken from test pieces and from the same bloom during rolling into a French Railway standard 36-kgr. (72.57 lb. per yard) rail. This bloom is the one of which we have already given a macrograph (fig. 2) and which was made from an ingot rolled deliberately before complete solidification.

If we compare the macrograph of the initial bloom with that from the finished rail (fig. 10) we may be astonished *a priori*, that the internal ring of impurities which on the bloom is some distance from the surface, should, in the finished rail, be level with it at certain points, and in particular at the radii between the web and the foot : the macrograph taken after the second pass (fig. 8) at once explains this abnormality. Observations of this kind will, in certain cases, result in the grooves in the rolls in the rolling mills, being cut to a more scientific design.

(1) See the article cited above.

[621 .132.8]

Proposed turbine locomotive design.

Figs. 1 to 3, p. 923 and 927.

(*Railway Mechanical Engineer.*)

The International Railway Fuel Association held its 20th annual convention on the 8 to 11 May inclusive in Chicago.

Twelve papers by individuals and thirteen reports of committees were read before it.

Amongst these latter was one dealing with the turbine locomotive and containing a detailed description of a proposed turbo-electric locomotive.

The committee responsible for this proposal was composed of men from the railways and also from the locomotive builders. It considered the various trial locomotives that have been built in Europe as well as other designs suggested by Messrs. Ljungström, of from 4 000 to 8 000 H. P. corresponding to a drawbar pull of 78 000 to 191 000 lb. and having a total weight of 830 000 lb. for the higher power.

As a result of its investigation into earlier schemes and of its enquiries into recent practice, the committee put forward the turbine locomotive the particulars of which given below have been taken from the *Railway Mechanical Engineer.*

* * *

Proposed turbine locomotive design.

The committee, after carefully checking the progress made in Europe, believes that this type of locomotive deserves serious consideration. A locomotive of this type should have many advantages over the present type. We believe that the best method of bringing the turbine locomotive to the attention of this association is to make definite recommendations covering a specific design.

This has been done, and we submit herewith a design for a 2 500 H. P. steam turbine locomotive suitable for either heavy passenger or fast freight service, the starting tractive force of this locomotive to be 100 000 lb. and the maximum speed 65 miles per hour.

The power for this locomotive is obtained from a steam turbo-electric generating unit furnishing electric current to motors geared to the driving axles. The steam turbine drives the electric generator through a set of single-reduction gearing.

Steam at 400 lb. pressure and 700° F. maximum temperature, at the turbine throttle, is furnished by a water-tube boiler of compact design. The exhaust steam from the turbine is condensed by a closed feed water heater, an air-cooled condenser at the front of the locomotive and a combined rotary jet condenser and vacuum pump, having the jet cooling water cooled by an air-cooled radiator at the rear end of the locomotive.

The general construction of this locomotive consists of a main frame of cast steel 75 feet long carried on two 10-wheel trucks, each truck to have three pairs of driving and two pairs of guiding wheels, one pair at each end. The greater portion of the main frame is to have a sheet steel housing on top of it, the cross section to come within the road clearance limits.

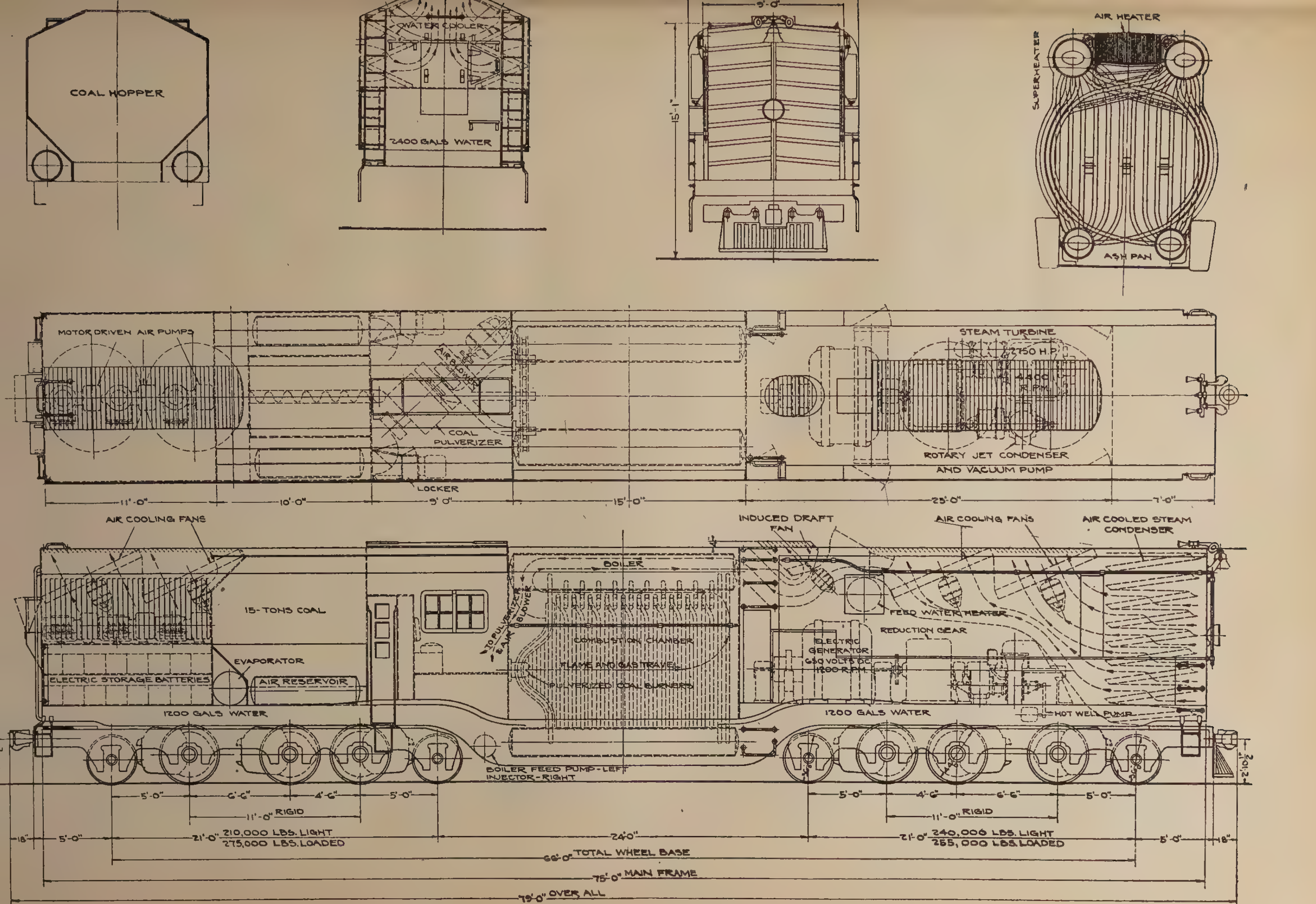


Fig. 1. — Plan, elevation and cross sections of steam turbo-electric locomotive laid down by the committee.

The general arrangement of the parts of the locomotive, beginning at the front end, is the air-cooled steam condenser and cooling fans, steam turbine, rotary jet condenser and vacuum pump, electric generator, steam boiler, cab containing coal pulverizer and all locomotive controlling apparatus, coal bunker, water tank, water cooling radiator and cooling fans, an electric storage battery to start and operate the motor-driven auxiliaries, and to furnish electric current for the headlight and cab lighting, and an evaporator to evaporate all the raw water from the storage tanks, and pass it on as steam to the condenser. This will insure clean, pure feed water for the boiler.

Transmission.

A single-unit type construction is to be used instead of the usual double-unit arrangement of engine and tender. This makes possible a well-car type design at the center of the main frame between the trucks and permits the use of a very compact design of water-tube boiler with comparatively large combustion chamber.

The unit type construction eliminates the use of the usual drawbars, chafing plates and buffers, and hose or flexible metallic connections for water, air and steam which would be required if a two unit arrangement was used. A satisfactory design has been worked out for the main frame which has to be cast steel in one piece. Each truck frame is also to be cast steel of one-piece construction.

Electric transmission is to be used to permit the most flexible arrangement and the location of the driving wheels at both ends of the locomotive. This provides maximum weight on driving wheels and maximum tractive force at starting. Roller bearings are to be used on all driving and truck axle journals.

Steam boiler.

The steam boiler will be of the water-tube type, of compact design. It will carry a maximum steam pressure of 450 lb. and have a superheater to give a maximum steam temperature of about 700° F. The design of the boiler is such as to provide rapid circulation of the water in it, which will insure maximum evaporation from the heating surface the greater portion of which is in the firebox. The weight of this boiler and the amount of water carried in it will be about one-third of the weight and water capacity of a standard locomotive boiler. At the back of the firing end of the boiler an ignition pocket is provided so that powdered coal or oil can be used for fuel.

Steam ash and soot blowers are to be provided for removing the ash and soot from the tubes in the boiler, an ash pan being located under the boiler firebox. The ashes are to be removed from this ash pan by means of a steam ash blower through a door provided at the front of the pan.

An air heater is to be used for heating the air for combustion to a high temperature before it is blown into the combustion chamber. The air is heated by the waste gases from the firebox after they have passed through the superheater. The flow of the air through the heater will be counter-flow to the flow of the waste gases, which will provide highest air temperature and highest efficiency.

A 10-H. P. motor-driven exhaust fan will be used to provide induced draft through the combustion chamber, superheater and air heater and to discharge the gases from the top of the locomotive.

The fuel will be powdered coal. A 50-H. P. motor-driven unit pulverizer with a capacity of 5 000 lb. per hour will be located in the cab between the boiler and the coal hopper which has a capacity of about 15 tons. The coal from the storage hopper will be conveyed to the pulverizer by a screw conveyor similar to that now used on stoker-fired locomo-

tives. The amount of coal and heated air entering the pulverizer can be regulated to suit requirements. All air for combustion is heated to a high temperature. About 25 % of this air will pass through the pulverizer for conveying, drying and heating the pulverized coal. About 25 % of the air will be blown into the coal and air pipe before it enters the burners. The remaining 50 % of air will be blown into the combustion chamber, as secondary air, at several points around the ignition pocket.

Pulverized coal burners.

Three flat-flame pulverized-coal burners are to be used, one in the center and one on each side of the ignition pocket of the combustion chamber in the boiler. The construction of these burners is similar to a gaslight burner to give a turbulent, thorough mixing of the air and pulverized coal.

The burners will give a short, intensely hot flame which will ignite close to the burner. The three burners will provide a wide range of capacity. The center burner is to be used when starting the fire or for maintaining heat for holding steam pressure. The two outside burners are to be used when the locomotive is working at low or medium capacity. All three burners are to be used when the locomotive is worked to maximum capacity. Each burner is to have a capacity range of over 50 %. It will not be necessary to dry or crush the coal before placing it on the locomotive any more than would be required for a stoker-fired locomotive.

The turbine and generator.

The steam turbine will be designed to meet the shocks and additional stresses of operating in a locomotive. This will require some modification of standard engineering practice now used in laying out this type of equipment for stationary power plants. The turbine will, however, be based as nearly as possible on a unit of approximately 4 400 revolutions per minute, combining the best practice available. The maximum efficiency of the turbine will be selected to give minimum steam consumption at full load in order to favor the condenser operation. Steam consumption will be about 9 lb. per horse-power-hour at 26 inches vacuum, and at full speed.

The turbine will be geared to a generator operating at 1 200 revolutions per minute or higher. The ideal speed cannot be determined until the design is actually laid down. The generator will be a d. c. machine with a field so arranged that the main voltage may be modified over a range from 650 down to a safe value for the motors under starting conditions. There will be an exciter on the shaft of the main generator to furnish current for the control, compressor, battery charging and auxiliaries.

The motors will be arranged for series-parallel connection in order to secure maximum efficiency and the best operating combination for the main generator and the traction motors. The traction motors will be of approximately 400 H. P. rating each. The characteristics of the series motor are ideal for traction purposes in ensuring an even torque up to the slipping point of the wheels. The motors will absorb the full output of the generator at any speed of the locomotive.

Condensers.

The condensing problem presented by this locomotive shows that it will be called upon to condense 30 000 lb. of steam per hour at a 26-inch vacuum under maximum operating conditions. The design will be such that 1/6 of this amount of steam will be bled from the turbine for the purpose of heating the feed water; 3/6 of the steam will be con-

densed in the main air-cooled condensers; 2/6 will be condensed in the rotary jet condenser and vacuum pump.

The condensing system will be divided into two parts : the actual steam condensers, which will operate at the front of the locomotive and will be required to condense 15 000 lb. of steam per hour, and the watercooling condensers or radiators which will be required to dissipate heat equivalent to 10 000 lb. of steam at a 26-inch vacuum and which will function at the rear of the locomotive as a supplement to the rotary jet condenser and vacuum pump.

At the front end we have arranged to incorporate approximately 280 square feet gross frontal area of copper condensers. These condensers will be built along the same principle as an automobile radiator, being a multiplicity of flattened tubes over which fins are placed and bonded by various methods. The condensers will be built entirely of copper, using seamless tubing, which in turn will be brazed into ingot-iron or copper head sheets and distributor tanks. The actual condensers will be built in sections approximately 12 inches in width by 48 inches in length. These sections will be attached by unions to a central header and return lines. Any section can readily be removed for servicing or cleaning and replaced by merely removing two or three nuts. The entire system will be protected by a fine mesh screen (5 or 6 mesh) to overcome any tendency toward clogging due to bugs, grasshoppers and other foreign matter which may be carried in with the cooling air.

Each set of condensers will be supplemented by two propeller-type fans using the same principles as are embodied in aeroplane propellers. Each fan will require 25 H. P. for operation and will move approximately 150 000 cubic feet of air per minute. The fans are to be arranged so that all air discharges upward, inasmuch as air will be discharged from the condensers at points over the fan with a velocity as high as 3 000 feet per minute. This would be objectionable for either downward or sidewise discharge when passing stations.

A hot-well pump will be required to return the condensation from the air-cooled steam condenser to the boiler feed pump.

The rear cooling system will act supplementary to the rotary jet condenser and vacuum pump. This cooler will be required to do somewhat more work than the other end, inasmuch as on the front end you will be dealing with steam at approximately 126° temperature, while the cooler must handle water as low as 10° above atmospheric temperatures. For this reason the same fan equipment will be required for the rear end cooler even though there are actually less heat units to be dissipated. The rotary jet condenser and vacuum pump and the hot-well pump will be driven from the turbine shaft. The rotary jet condenser will have a booster pump on the same shaft to return the circulating water to cooling system at the rear end of the locomotive. After being cooled, the water returns to a storage tank under the cooler and is again pumped through the rotary jet condenser and vacuum pump.

A closed-type feed water heater will receive steam at 60 lb. pressure, bled from the steam turbine. This heater will raise the temperature of the feed water to about 317° F. before entering boiler. A steam-jet heater will be used to heat the boiler feed water before it enters the boiler feed pump which is of the centrifugal type, turbine driven. The jet heater is to receive the exhaust steam from this steam turbine, the condensation from the closed type heater and the water from the hot-well pump, to mix with water discharged from the booster pump connected to the rotary jet condenser.

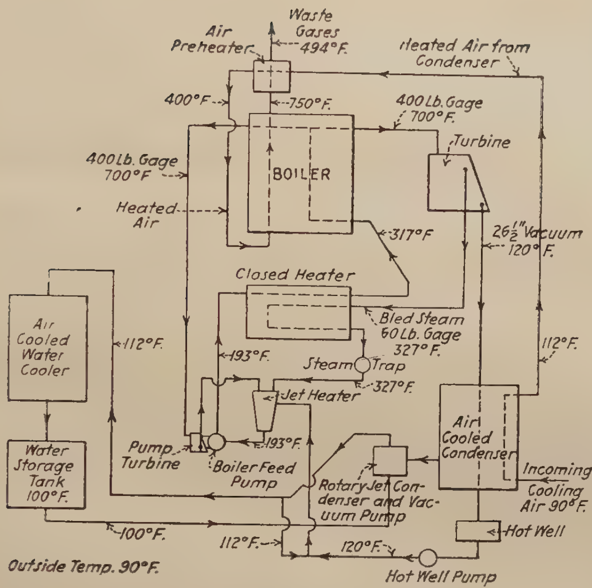


Fig. 2. — Heat flow diagram of the proposed turbo-electric locomotive.

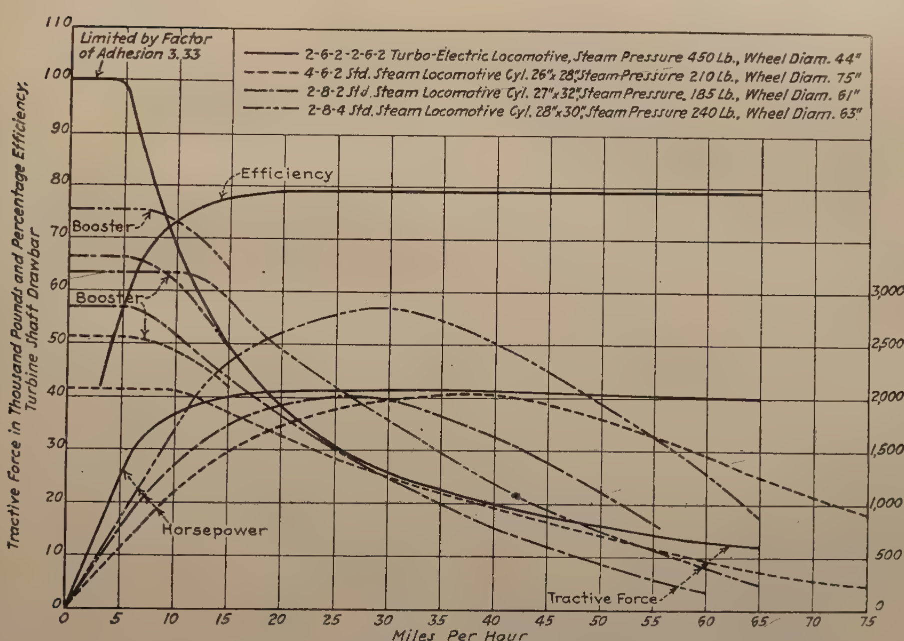


Fig. 3. — Drawbar horsepower — tractive force — efficiency-speed curves.

Feed water heater, pump and injector.

The maximum temperature of the feed water before entering the boiler feed pump will be 193° F. The pump will discharge the feed water through the closed type heater where it will be heated to about 317° F. as stated above. A hot water injector will be used to supplement the boiler feed pump and will receive water from the line supplying water to the rotary jet condenser and vacuum pump.

A steam-heated evaporator, receiving steam bled from the steam turbine, will be used to evaporate all water passing from the storage tank to the rotary jet condenser cooling water storage tank. The water evaporated in the evaporator will be drawn as steam into the rotary jet condenser and condensed and returned to the cooling circulating system or to the boiler as feed water.

The evaporator is located between the coal and water storage and provides a positive means of purifying the water to be used in the boiler. No water treatment of any kind will be required for the water entering the evaporator. The amount of make-up for boiler feed would be comparatively small except when the locomotive is used for hauling passenger trains and steam is required for heating.

An electric storage battery of about 150 cells and about 90 kilowatt-hours capacity will be used and located at the sides of the water storage tank at the rear end of the locomotive. This storage battery is of sufficient capacity to operate the coal-pulverizer motor, induced-draft-fan motor, air-pump motor and lighting system for about two hours. This will provide a convenient means of operating these auxiliaries independently of the main turbo-generating set or any outside source.

A heat-flow diagram has been made to show the heat flow and also the cycle of operation for the water, steam and air used in the power generating plant. This diagram may at first appear complicated, but the cycle and the operation of the apparatus on the locomotive is very simple and requires the least possible attention.

Heat balance.

The heat balance has been calculated respectively for the standard steam locomotive and the turbo-electric locomotive. The figures are shown in the table below.

Heat balance of a standard steam locomotive.

Loss to sparks	4 %
Loss to gases	18 %
Loss to ashpan	4 %
Loss to radiation	4 %
Loss to air and boiler pumps	6 %
Loss to exhaust	55 %
Loss to friction	1 %
Total losses	92 %
Returned by feed water heater	10 %
Useful work	8 %

Heat balance of a steam turbo-electric locomotive.

Loss to sparks	2 %
Loss to gases	12 %
Loss to ash pan	2 %
Loss to radiation	3 %
Loss to auxiliaries	4 %
Rejected by condensers	52 %
Loss to generators, motors and gear reduction	7 %
Loss to friction	1 %
Total losses	83 %
Returned by feed water heater	14.5 %
Returned by use of condenser heated air	0.5 %
Returned by air heater	7.5 %
Useful work	17.0 %

The percentage of useful work obtainable from the coal for the standard steam

locomotive, is 8 % as compared with 17 % for the turbo-electric locomotive. This indicates that the turbo-electric locomotive will use less than half the coal used by the standard steam locomotive when doing the same amount of work.

The turbo-electric locomotive should also use very much less coal during stand-by time than the standard steam locomotive, on account of the use of pulverized coal for fuel.

Horsepower, tractive force and efficiency-speed curves have been made up to cover the comparison of the turbo-electric locomotives with several standard steam locomotives of about the same or greater horsepower capacity. These curves clearly indicate that the turbo-electric locomotive has greater tractive force at all speeds than the standard steam locomotive of practically the same horsepower, and also that it has considerably greater tractive force at low speed and also at high speed, than a standard steam locomotive having considerably greater horsepower.

The turbo-electric locomotive has a high tractive force at low speeds, as shown on the diagram, which gives it a distinct advantage over the standard steam locomotive. In other words, the turbo-electric locomotive is able to produce a greater tractive force than the standard locomotive at any speed, due to its being able to work its power plant at practically full capacity under all conditions. It can, therefore, handle greater tonnage under all conditions. This makes the turbo-electric locomotive practically on a par with the electric locomotive, within the limits of its power plant capacity.

The turbo-electric locomotive can operate where any standard steam locomotive can be used and can also be designed to operate over electrified zones with electric current received from an overhead wire or third rail.

The turbo-electric locomotive should have many advantages over the standard steam locomotive, particularly when equipped to burn pulverized coal, which should make operation practically as flexible as when oil is used for fuel. The standby - losses, with powdered coal should be very low and the time required for cleaning ash pans reduced to a minimum. The operation should also be practically smokeless.

The use of boiler feed water evaporated and purified on the locomotive should reduce the cost of water to a minimum. It should also reduce the labor and maintenance cost for the locomotive boiler and keep it clean and efficient at all times, and practically eliminate the necessity for boiler washing.

[313 : 625 .143.3

Statistics of rail breakages during the year 1927.

In accordance with the resolution passed at the London Congress, 1925 ([1]), we publish below the information which has been sent in by the adherent administrations on the subject of the breakages of rails which occurred on their systems during the year 1927.

([1]) See *Bulletin of the Railway Congress*, March 1926, p. 240.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ARGENTINE. **Buenos-Ayres and Pacific Railway.**		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	1	1 189.7	0.53	...	...	...	1	1 189.7	0.53	7	1 189.7	3.67	69	1 189.7	36.22	12 to 18
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	...	...	...	1	1 719.9	0.36	4	1 719.9	1.45	4	1 719.9	1.45	5	1 719.9	1.81	19
Total. . .	1	1 189.7	0.53	1	1 719.9	0.36	5	2 909.6	1.07	11	2 909.6	2.35	74	2 909.6	15 84	...
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Buenos-Ayres Western Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	1	1 665	0.373	1	1 665	0.373	6	1 665	2.239	15	1 665	5.597	18.4
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	4	376	6.612	1	376	1.653	1	376	1.653	2	376	3.306	...	...	...	18.4
Total. . .	4	376	6.612	2	2 011	0 609	2	2 041	0.609	8	2 041	2 435	15	1 665	5.597	...

Buenos-Ayres and Pacific Railway:

Number of train-miles : 9 180 710.
Total number of fractures : 92.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 6.26.

Buenos-Ayres Western Railway:

Number of train-miles : 5 693 088.
Total number of fractures : 31.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 33.836.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Length of single track with each rail profile.	Age of rails :											
		5 years and less.						6 to 10 years				
		Year of manufacture.	Number of fractures			Length of single track of this class.	Number of fractures per 1 000 km or per 625 miles.	Year of manufacture.	Number of fractures			Length of single track of this class.
			In the length of the rail.	At the joint.	Total.				In the length of the rail.	At the joint.	Total.	
1	2	3	4	5	6	7	8	9	10	11	12	13
	Miles.					Miles.						Miles.
BELGIUM.												
Belgian National Railway Company.												
Light rails :												
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.												
Weight : 38 kgr. (76.60 lb. per yard), profile adopted in 1863 (steel).	124.3	...	...	...	...	...	...	...	...	...	...	...
Weight : 40.65 kgr. (81.94 lb. per yard), profile adopted in 1898.	1 542.3	1923 to 1927	1	1	*2*	241.7	5.10	1918 to 1922		4	*4*	83.9
Medium rails :												
of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).												
Weight : 50 kgr. (100.79 lb. per yard), profile adopted in 1910.	1 897.7	1923 to 1927	4	11	*15*	1 180.6	7.90	1919 to 1922	5	9	*14*	452.7
Weight : 52 kgr. (104.82 lb. per yard), profile adopted in 1886.	254.1	...	...	...	...	...	...	...	...	...	...	...
Heavy rails :												
of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.												
Weight : 57 kgr. (114.90 lb. per yard), profile adopted in 1907.	302.6	...	...	...	...	...	...	...	...	...	...	...
Total. . .	4 121.0	...	5	12	*17*	...	...	...	5	13	18	...

Number of train-miles : 43 658 922.

Total number of fractures : 297.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 42.27.

N. B. — Three fractures due to the silvery oval mark have been identified but there is no doubt that other fractures due to the

N. B. — Fractures at points and crossings have not been included in these statistics.

Age of rails: 14 to 20 years. Year of manufacture.	14 to 20 years. Number of fractures. In the length of the rail.	At the joint.	Total.	More than 20 years. Year of manufacture.	More than 20 years. Number of fractures. In the length of the rail.	At the joint.	Total.	Length of single track with profiles of 14 years and more.	Number of fractures per 1 000 kilometres, or per 625 miles of these classes.	Total number of fractures for the whole of the system.	*Maximum axle load.*
15	16	17	18	19	20	21	22	23	24	25	26
								Miles.			Pounds.
...	...	...	...	...	10	1	*11*	124.3	55.00	*11*	
8 to 1914	17	22	39	1898 to 1907	37	43	*80*	1 216.7	60.70	*125*	
) to 1914	11	34	45	...	...	...	...	264.1	105.75	*74*	44 090
1908	2	...	2	1887 to 1907	21	17	*38*	254.1	97.80	*40*	
to 1914	11	18	29	1907	1	17	*18*	302.6	96 5	*47*	
...	41	74	115		69	78	*147*	...	...	*297*	

Percentages of fractures:	At the joint.	Outside the joint.
I. *Light rails*	52.20	47.80
II. *Medium rails*	62.28	37.72
III. *Heavy rails*	74.47	25.53

have not been reported owing to the staff being still too inexperienced to trace all cases.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load.
Chimay Railway.	No fractured rail was reported.															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
French Northern Railway (Nord Belge Lines).		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	3.919	...	...	2.760	...	...	6.741	...	18.2
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	...	60.833	...	...	1.351	...	1	14.509	43	10	67.314	92	...	41.767	...	19.7
Heavy rails: of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	...	...	...	...	...	...	...	...	...	...	1.388	...	...	0.032	...	19.7
Total.	...	60.833	...	...	1.351	...	1	18.428	34	10	71.462	87	...	48.540	...	...

Number of train-miles : 2 160 116.
Total number of fractures : 11.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 32.

PARTICULARS OF THE FRACTURES.

Medium rails.

Rails from 10 to 15 years of age :

1 failure at the joint; clean and new breakage over the whole section of the fracture with silvery oval mark ; number of pieces : 2.

Rails from 15 to 20 years of age :

3 failures at the joint : old fractures much rusted not extending to the outer surface of the head ; number of pieces for each fracture : 2.

1 failure at the joint : 2 breakages of which 1 fresh and clean over the whole section without silvery oval mark and 1 with old part much rusted not extending to the outer surface of the head ; number of pieces : 3.

1 failure at the joint : fracture with old part much rusted extending to the outer surface of the foot ; number of pieces : 2.

2 failures at the joint : old fractures showing much rusted part extending to the outer surface of the head ; number of pieces for each fracture : 2.

2 failures at the joint : fresh and clean breakages over the whole of the rail section without silvery oval mark ; number of pieces for each fracture 2.

1 failure at the joint : clean and new breakage over the whole section with silvery oval mark ; number of pieces : 2

10

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			Maximum axle load
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Belgian National Light Railway Company. (*)																English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	4	...	...	...	...	...	12	...	...	681	...	...	9.8

(*) On part of system only (2 193 miles).

Number of train-miles : 21 748 000.
Total number of fractures : 697.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 199.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CONGO COLONY. Lower-Congo to Katanga Railway.		Miles.			Miles.						Miles.					English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	62	...	...	106	...	...	...	...	2	329	3.77	...		...	13.8

Number of train-miles : 1 553 500.
Total number of fractures : 2.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 7.7.

Notes. — Length of system : 802 km. (498 miles).
Both fractures occurred outside the joint.
The fractures can be grouped under B a 2.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
BULGARIA. State Railways.		Miles.						Miles			Miles			Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	1	142	4	...	...	...	9	185	30	5	225	14	30	792	23	13.8

Number of train-miles : 5 841 000.
Total number of fractures : 45.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 48.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CHINA. South Manchuria Railway Company.		Miles.			Miles.			Miles.			Miles.			Miles.		Pounds
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	10	11.097	560.0	21	66.633	195.8	56	82.149	426.9	28	65.446	265.8	28	38.277	454.6	51 2 5
Medium rails : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	61	366.430	108.5	14	407.064	21.4	...	...	...	...	...	...	...	...	...	51 235
	74	377.527	121 8	35	473.697	48.9	56	82.149	426.9	28	65.446	265.8	28	38.277	454.6	...

Number of train-miles : 8 842 348.
Total number of fractures : 221.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 155.3.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
DENMARK.		Miles.			Miles.			Miles.			Miles			Miles.		
State Railways.																
Light rails:																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	0	30.36	0	2	134.14	9.3	3	207.76	9.0	3	233.01	8.0	161	741.22	135.0	(a) (b) (c)
Medium rails:																
of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	2	38.29	32.5	1	169.85	3.7	0	55.19	0	2	160.44	7.8	1	69.68	8.9	(d)
Total . . .	2	68.65	18.0	3	303.99	6.1	3	262.95	7.1	5	393.48	7.9	162	810.90	124.3	

Number of train-miles : 12 071 780.
Total number of fractures : 175.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 90.1.

(a) 24 250 lb. (45.35 lb. per yard). — (b) 28 660 lb. (64.50 lb. per yard). — (c) 33 070 lb. (74.59 lb. per yard). — (d) 33 070 lb. (90.70 lb. per yard).

DESCRIPTION OF RAILS.	Total number of fractures.	A				B												
		Percentage of fractures				a)				b)				c)		d) Number of pieces rails broken into		
		at the joint		outside the joint		1.		2.		1.		2.						
		number	per-centage	number	per-centage	number	per-centage	number	per-centage	number	per-centage	number	per-centage	number	per-centage	two pieces	three pieces	four pieces
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Light rails :	169	112	66.2	57	33.8	7	4.1	44	26.0	42	24.9	17	10.0	59	35.0	150	18	1
Medium rails :	6	4	66.7	2	33.3	0	0.0	3	50.0	2	33.3	1	16.7	0	0.0	5	1	0
Total.	175	116	66.2	59	33 8	7	4.0	47	26.9	44	25.1	18	10.2	59	33.8	155	19	1

A. — Percentage of fractures in the respective portions of the rails covered by and clear of the fishplates.

B. — Percentage of fractures according to the appearance of the fracture :

a) Fresh and clean fracture through the whole of the rail section : 1. With silvery oval mark ; 2. Without silvery oval mark.

b) Fractures, part of which are old and much rusted, extending to the outer face of the foot or head of the rail :

1° When the rusted part is in the foot;
2° When the rusted part is in the head.

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail.

d) Number of pieces into which the rail is broken.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
South Funen Railway.		Miles.						Miles.			Miles.			Miles.		
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	26.7	...	...	...	...	2	19.9	62	1	3.1	200	21	79.5	161	...

Number of train-miles: 787 510.
Total number of fractures: 24.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles: 190.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
EGYPT. State Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	0	71.5	0	11	734.4	9.30	18.85
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	1	482.2	1.29	2	124.3	10	2	222.4	5.58	1	341.8	1.81	4	63.4	39.21	18.85
Total . . .	1	482.2	1.29	2	124.3	10	2	222.4	5.58	1	413.2	1.81	15	797.8	11.68	...

Number of train-miles: 12 123 470.
Total number of fractures: 21.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles: 10.76.

TYPE OF RAILS.	On the straight.		On curves.		Remarks.
	Number.	Age.	Number.	Age.	
1	2	3	4	5	6
EGYPT. State Railways.					
Flat 47 kgr. (94.75 lb. per yard)	1	3	...	...	
	1	8	...	...	Stock rail
	1	10	...	...	
	1	15	...	...	
	1	15	...	...	Stock rail
	1	16	...	...	
	1	21	...	...	Stock rail
Flat 46 kgr. (92.73 lb. per yard)	...	...	1	22	Stock rail
	1	22	...	...	
	1	23	...	...	
Flat 42 kgr. (84.67 lb. per yard)	2	26	...	...	Stock rail
Flat 40 kgr. (80.63 lb. per yard)	...	...	1	23	
Flat 37.4 kgr. (75.39 lb. per yard)	...	...	1	36	
	1	33	...	...	
	2	36	...	...	
	1	37	...	...	
Flat 36 kgr. (72.57 lb. per yard)	3	37	...	...	

Percentage of fractures at the joint : 4.76 %.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SPAIN.														Miles.		English tons.
Central Aragon Railway.																
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	5	186	...	12.8

Number of train-miles : 695 804.

Total number of fractures : 5.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Madrid to Cacérès and Portugal and West of Spain Railway.														Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	168	483	217	14 8

Number of train-miles : 2 128 8C0.
Total number of fractures : 168.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 490.

Note:

B. — Percentage of failures according to the appearance of the section :
- *a*) New clean break over the whole section of the rail :
  1. With silvery oval mark : 81.
  2. Without silvery oval mark : 8.
- *b*) Fracture partly old and rusted extending to the outside surface of the flange or head of the rail :
  1. Rusted surface in the flange of the rail : 73.
  2. Rusted surface in the head of the rail : 1.
- *c*) Fracture with old and rusted surface not extending to the exterior surface of the flange or of the head of the rail : 5.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.								5 to 20 years :				Miles.		Pounds
Madrid, Saragossa and Alicante Railway.											Miles.					
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	15	137.6	67.72	35 275
Medium rails :																
of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	...	...	...	...	...	...	...	...	...	2	1 348.3	0.92	...	...	...	35 275
Total. . .	...	...	..	...	...	...	...	...	...	2	1 348.3	0.92	15	137.6	67.72	...

Number of train-miles : 13 882 933.
Total number of fractures : 17.

Number of fractures per 10 000 000 train-kilome res or 6 250 000 train-miles : 7.61.

Particulars of the fractures, according to the appearance of the section

(*Madrid, Saragossa and Alicante Railway*).

A. Percentage of failures at the joint (that is to say in the part of the rail covered by the fishplate) and outside the joint.		B. Percentage of failures according to the appearance of the section.					
		a) New clean fracture over the whole section of the rail.		*b*) Fracture partly old and rusted extending to the outer surface of the flange or head of the rail.		*c*) Fracture with old and rusted surface not extending to the exterior surface of the flange or of the head of the rail.	*d*) Number of pieces into which the rail was broken.
At the joint.	Outside the joint.	1. With silvery oval mark.	2. Without silvery oval mark.	1. Rusted surface in the flange of the rail.	2. Rusted surface in the head of the rail.		
...	100.0	...	47.06	47.06	...	5.88	2

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Medina del Campo to Zamora and Orense to Vigo Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	24 (1)	109	136	14.8
North of Spain Railway.																
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	2	1 167	1.06	1	1 167	0.53	71	1 167	37.80	37 480
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	16	1 552	6.40	3	1 552	1.20	5	1 552	2.00	2	1 552	0.80	...	...	...	37 480
Total . .	16	...	...	3	...	...	7	...	...	3	...	...	71	...	...	...

Total number of train-miles : 18 579 991.
Total number of fractures : 100.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 33.

(1) Of the 24 fractures, 3 occurred at the part of the rail covered by the fishplate and the other 21 outside the joint.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Great Southern of Spain Railway.														Miles.		Pounds
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	17	123	86	30 645

Number of train miles : 414 783.
Total number of factures : 17.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 255.

1	Rolled : 1923-1927.			Rolled : 1918-1922.			Rolled : 1913-1917.			Rolled : 1908-1912.			A. S. C. E. rail			
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
UNITED STATES OF AMERICA. Baltimore and Ohio Railroad.		Miles.			Miles.			Miles.			Miles.					Pounds
100 lb. per yard rails.	296	1 799	103	190	797	149	297	735	252	133	177	469	13	100	81	70 000
130 lb. per yard rails.	56	505	68	8	84	60	...	...	...	...	...	...	...	...	...	70 000

It will be noted that 64 130 lb. rails and 929 100 lb. rails have been included in this report. The following tables show the percentage of broken rails to all failed rails, and also divides them into four classes, according to the location and nature of the break :

130 lb. per yard rail.	Number.	Per cent.
A. Plain clear breaks outside splice bars	12	5.7
B. Transverse fissures outside splice bars. . . .	31	14.9
C. Plain clear breaks inside splice bars	7	3.4
D. Diagonal breaks through web and head at joints	14	6.7
E. Split web failures outside splice bars	4	1.9
F. Crushed and split heads.	134	64.5
G. Broken bases	6	2.9
Total	208	100.0

Failures classed under headings *A*, *B*, *C* and *D*, a total of 64 or 30.7 % of all failures, are included in the report.

100 lb. per yard rail.	Number.	Per cent.
A. Plain clear breaks outside splice bars	234	15.7
B. Transverse fissures outside splice bars. . . .	386	25.8
C. Plain clear breaks inside splice bars . . .	72	4.8
D. Diagonal breaks through web and head at joints	237	15.9
E. Split webs outside splice bars.	108	7.2
F. Crushed and split heads.	453	30.3
G. Broken bases	4	0.3
Total	1 494	100.0

Failures classed under headings *A*, *B*, *C* and *D*, a total of 929 or 62.2 % of all failures, are included in the report as broken rails.

The classification of the failures as given is in accordance with the instructions contained in the final summary adopted by the London Congress, except that the records have not been kept in such detail as to sub-divide broken rails or transverse fissures according to the degree or extent of the oxidization.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Number of fractures.	Length of single track of this class.	Number of fractures per 625 miles.	Maximum axle load, pounds.
Central of Georgia Railway.				
	Rails less than 5 years of age.			
Medium rails :				
85 lb. to 105 lb. per yard	127	420	189	61 700
	Rails 5 to 10 years of age.			
Medium rails :				
85 lb. to 105 lb. per yard	16	270	37	61 700
	Rails 10 to 15 years of age.			
	None.			
	Rails 15 to 20 years of age.			
Medium rails :				
85 lb. to 105 lb. per yard		4	313	61 700
	Rails more than 20 years of age.			
	None.			

Number of train-miles : 4 348 439.
Total number of fractures : 145.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 208.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Delaware and Hudson Railway.		Miles.			Miles.											Pounds
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	76	340	139	50	383	81	59	67	550	...	...	...	...	...	...	±75 000

Number of train-miles : ± 4 000 000.
Total number of fractures : 185.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 289.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Illinois Central System. (*)		Miles			Miles.			Miles								Pounds
90 lb. per yard ARA-A rails.	379	2 107	115	785	1 395	352	552	390	884	67	59	710	...	...	...	63 700
110 lb. per yard R. E. rails.	10	260	21	...	...	...	...	...	...	...	...	...	...	...	...	63 700
Total. . .	389	2 367	103	785	1 395	352	552	390	884	67	59	710	...	...	...	63 700

(*) Year ending 1 November 1927.

Number of train-miles : 30 858 354.
Total number of fractures : 1 793.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 363.

Percentage of breakage covered by fishplates : 14.5.
— — clear of fishplates : 85.5.
— — with silvery oval mark : 31.7.
— — without silvery oval mark : 68.3.

This report does not embrace all of the information required, as that requested under section II is not available from the records.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Kansas City Southern Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		Pounds
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	3	264	7	18	170	66	17	69	154	46	240	120	23	80	180	63 500

Number of train-miles : 3 603 000.
Total number of fractures : 107.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 186.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Lehigh & New England Railroad.		Miles.			Miles.			Miles.								Pounds
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	0	24	0	12	38	197	3	44	42	...	...	...	...	...	...	73 000

Number of train-miles : 545 797.
Total number of fractures : 15.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 172.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		Pounds
Lehigh Valley Railroad. (*)																
Medium rails:																
100 lb. per yard rails.	...	...	...	2	42.39	29.49	11	146.40	46.96	1	4.05	154.32	...	...	...	68 330
Heavy rails:																
110 lb. per yard rails.	...	...	...	...	...	...	...	...	11.95	1	1.42	440.14	...	...	...	68 330
136 lb. per yard rails.	9	524.95	10.72	18	259.52	43.35	1	1.19	525.21	...	...	...	...	...	...	68 330

(*) From 1 November 1926 to 31 October 1927.

Number of train-miles : 11 117 733.
Total number of fractures : 43.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 24.1

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	ROAD.	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
New York Central Lines.			Miles.			Miles.			Miles.			Miles.			Miles		Pounds
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	New York Central-East	21	67.47	195.00	22	352.35	38.00	21	365.45	40.00	31	417.40	46.00	...	406.15	...	...
	New York Central-West.	...	...	...	...	...	...	...	24.00	...	2	13.00	96.15	1	8.00	78.12	65 000
	O. C. Lines.	...	...	...	...	...	...	5	56.60	55.00	...	7.26	...	...	...	...	...
	Rutland	...	...	...	...	...	...	...	...	...	2	31.83	39.27	49	124.14	246.69	57 200
Medium rails: of 42.5 to 52.5 kgr. per m. (85 to 105 lb. per yard).	New York Central-East	149	1 565.20	58.00	96	999.85	60.00	123	451.43	160.00	28	127.90	138.00	19	38.70	312.00	64 000
	New York Central-West.	5	910.00	3.43	31	734.00	26.40	25	348.00	44.90	25	143.00	109.27	7	79.00	55.38	65 000
	O. C. Lines.	5	265.99	12.00	17	122.70	87.00	5	22.82	137.00	1	13.11	48.00	...	...	...	...
	Boston & Albany	76	331.44	142.10	21	118.75	110.50	...	...	...	...	...	...	...	...	...	...
	Pittsburgh & Lake Erie.	...	...	...	...	...	...	14	22.42	390.28	5	19.76	158.15	...	...	...	78 000
	Cleveland, Cincinnati, Chicago & St. Louis.	10	783.00	7.98	31	805.00	24.16	...	...	...	...	...	...	...	...	...	...
	Michigan Central	40	612.82	40.80	145	526.09	172.26	...	...	...	...	...	...	...	...	...	62 000
	Rutland	3	128.02	14.64	1	75.46	8.28	4	48.41	51.65	2	17.79	70.26	...	...	...	57 200
Heavy rails: of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	New York Central-East	29	366.13	49.00	...	...	...	...	...	...	...	...	...	...	...	...	64 000
	New York Central-West.	0	159.00	...	...	...	...	...	...	...	...	...	...	...	...	...	65 000
	Pittsburgh & Lake Erie.	1	275.49	2.27	2	102.90	12.15	...	...	...	...	...	...	...	...	...	78 000
	Michigan Central	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

ROAD.	Total number of fractures.	Number of fractures per 10 000 000 trains-kilometres or 6 250 000 train-miles.
New York Central-East	533	91.00
New York Central-West	96	28.55
New York Central - O. C. Lines	33	51.00
Boston & Albany	97	106.20
Pittsburg & Lake Erie	22	45.34
Cleveland, Cincinnati, Chicago & St. Louis	41	17.80
Michigan Central	185	No data.
Rutland	61	212.20

Note. — No failures on Indian Harbor Belt Railroad nor on Chicago Junction Railway.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Norfolk & Western Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		Pounds.
Light rails : of 42.5 kgr. per metre or 85 lb. per yard.	0	0	0	0	10	0	0	0	0	4	198	12 6	2	231	5.4	Steam locomotives : 68 000.
Medium rails : of 49.60 kgr. per metre (100 lb. per yard).	7	297	14.7	15	487	19.2	38	290	81.9	7	130	33.7	0	0	0	
Heavy rails : of 64.50 kgr. per metre (130 lb. per yard).	27	903	18.7	6	96	39.1	0	0	0	0	0	0	0	0	0	Electric locomotives : 75 000.
Total. . .	34	1 200	17.7	21	583	22.5	38	290	81.9	11	328	20.3	2	231	5.4	

Number of train-miles : 15 897 158.
Total number of fractures : 106.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 66.7.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Pennsylvania Railroad.		Miles			Miles.			Miles.			Miles.			Miles.		Pounds
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	10	26.22	238.4	227	156.85	879.5	1197	1 453.56	514.7	62 300
Medium rails : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	108	1184.65	55.7	368	691.27	332.7	1512	2 297.74	411.3	1272	1 769.05	443.1	1186	3 000.91	240.8	75 600
Heavy rails : of a weight equal to or greater than 52.6 kgr. per metre or 105.2 lb. per yard.	385	3 021.81	79.6	1005	1 753.13	358.3	611	757.98	573.8	...	0.96	...	...	0.25	...	75 600
Total. . .	493	4 206.46	73.3	1373	2 444.40	351.1	2133	3 081.94	432.6	1499	1 926.85	486.2	2383	4 454.72	334.3	...

Number of train-miles : 117 832 692.
Total number of fractures : 7 881.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 418.02.

	Fractures		Broken into									
	in joint. %	with silvery oval mark. %	2 pieces. %	3 pieces. %	4 pieces %	5 pieces. %	6 pieces. %	7 pieces. %	8 pieces. %	9 pieces. %	10 pieces. %	11 pieces. %
Light rails :	11.95	...	2.13	0 18	0.04	0.03	...	...	...	...	...	...
Medium rails :	36.10	6.03	47.10	6.14	0.67	0.22	0.04	0.01	0.02	0.01	...	0.01
Heavy rails :	18.17	3.93	39.96	2.91	0.39	0,09	0,03	...	0.02	...	...	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Reading Company.																
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	3	...	...	14	...	...	20	...	...	2	...	...	5	...	...	...
Heavy rails: of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	6	..	...	14	...	...	...	...	...	...	...	...	...	...	...	...
Richmond, Fredericksburg and Potomac Railroad.		Miles.			Miles.											Pounds
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	3	48	39	14	120	70	...	...	...	...	...	...	...	...	...	69 900
Heavy rails: of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	0	57	0	...	...	...	...	...	...	...	...	...	...	...	...	69 900
Total . .	3	105	18	14	120	70	...	...	...	...	...	...	...	...	...	...

Number of train-miles: 2 725 143.
Total number of fractures: 17.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles: 39.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Wabash Railway.		Miles			Miles.			Miles.			Miles.			Miles.		Pounds
Light rails :																
of a weight less than 42.5 kgr. per metre (85 to 105 lb. per yard).	...	...	...	...	...	...	...	1.4	...	5	29.6	106	364	920.3	247	67 500
Medium rails :																
of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	23	380.8	3	33	357.9	58	74	268.9	172	51	179.3	177	13	55.3	147	67 500
Heavy rails :																
of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	5	242.7	13	...	...	...	...	...	...	...	...	...	...	...	...	67 500
Total . . .	28	623.5	28	33	357.9	58	74	270.3	171	56	208.9	167	377	975.6	241	...

Number of train-miles : 14 903 245.
Total number of fractures : 568.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 238.

Number of fractures occurring in splice : 267 — 47.0 %.
Number of fractures occurring out of splice : 301 — 53.0 %.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
FINLAND. State Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails :																
of 42.5 kgr. per metre or 85 lb. per yard.	49	259	117.5	8	190	26.1	1	426	1.4	13	341	23.6	191	2 504	47.3	14.8
Medium rails :																
of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	14	131	66.3	...	100	...	...	72	...	...	...	...	...	...	...	14.8
Total. . .	63	390	100.3	8	290	17.1	1	498	1.2	13	341	23.6	191	2 504	47.3	...

Number of train-miles : 12 158 350.
Total number of fractures : 276.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 141.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Age of rails :					Length of single track.	Number of fractures per 1000 km. or per 625 miles.	Maximum axle load.
	Less than 5 years.	5 to 10 years.	10 to 15 years.	15 to 20 years.	More than 20 years.			
1	2	3	4	5	6	7	8	9
FRANCE. **State Railways.**						Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per m. or 85 lb. per yard	...	1	...	25	250	5 670	30	19.7
Medium rails : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	...	2	5	13	75	2 384	24	19 7
Heavy rails : Standard 55 kgr. per metre (110.87 lb. per yard).	...	...	...	...	...	38	...	19.7
Total . . .	...	3	5	38	322	...	...	...

Number of train-miles : 40 800 815.
Total number of fractures : 368.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 56.

	Percentage : Covered by the fishplates.		Percentage : Clear of the fishplates.
A. — Fractures of light rails.	31.5	A. — Fractures of light rails	68.5
— medium	71.7	— medium	28.3
— heavy	...	— heavy	...

		Light.	Medium	Heavy.
		Per cent.	Per cent.	
B. — a) Fresh and clean fracture in the whole of the rail section.	with silvery oval mark.	9.4	13.0	None.
	without silvery oval mark	29.7	16.3	
b) Fracture, part of which is old and much rusted, extending to the outer surface of the foot or the head of the rail	in the foot.	21.7	12.0	
	in the head	14.1	5.4	
c) Fracture part of which is old and much rusted, not extending to the outer surface of the foot or the head of the rail		25.1	53.3	

		2 pieces.	3 pieces.	4 pieces	5 pieces.	6 pieces	11 pieces
d) Number of pieces into which the rail is broken	light	251	15	5	1	3	1
	medium,	82	7	3	...	...	...
	heavy	...	...	...	...	...	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load.*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Alsace and Lorraine Railways (including the Guillaume-Luxembourg lines).		Miles.			Miles.			Miles.			Miles.			Miles.		English tons
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	14	...	8	180	28	8	176	28	71	1 201	37	For wagons : 15.7. For locomotives : 18.3.
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	1	295	2	1	85	7	16	80	124	10	171	36	7	80	51	
Total . .		295	2	1	99	6	24	260	57	18	347	32	78	1 281	38	...

Number of train-miles : 16 974 675.
Total number of fractures : 122.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 45.

Note. — This table does not include broken *machined rails* in points and crossings, that is to say, those of the nose, wing rails, points and stock rails.

	Percentage : Covered by the fishplates.		Percentage : Clear of the fishplates.
A. — Fractures of light rails	74.7	A. — Fractures of light rails	25.3
— medium	91.4	— medium	8.6
— heavy	...	— heavy	...

		Light.	Medium.	Heavy.
		Per cent.	Per cent.	
B — a) Fresh and clean fracture in the whole of the rail section	with silvery oval mark	11.5	14.3	None.
	without silvery oval mark	17.3	8.6	
b) Fracture, part of which is old and much rusted, extending to the outer surface of the foot or the head of the rail	in the foot	13.8	25.7	
	in the head	15.6	41.3	
c) Fracture, part of which is old and much rusted, not extending to the outer surface of the foot or the head of the rail	in the web	21.8	37.1	

		2 pieces	3 pieces	4 pieces	8 pieces
d) Number of pieces into which the rail is broken	light	64	17	6	...
	medium	22	9	3	1
	heavy	0	...	...	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Paris Circle Railways. (*)																
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	0	0.970	0	0	1.448	0	0	2.825	0	0	18.722	0	6	24.000	155	18.9
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	0	46.092	0	0	21.255	0	1	5.708	109	1	3.377	184	8	1.002	4 963	
Heavy rails: of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	0	2.367	0	...	548	0	...	...	...	...	...	...	...	...	...	
Total. . .	0	49.429	0	0	23.251	0	1	8.533	73	1	22.099	28	14	25.002	348	

(*) Broken rails (excluding those in points and crossings).

Number of train-miles : 1 666 665
Total number of fractures : 16.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 59.6.

	Percentage : Covered by the fishplates.
A. — Fractures of light rails	66.67
— medium	100.00
— heavy	...

	Percentage : Clear of the fishplates.
A. — Fractures of light rails	33.33
— medium	...
— heavy	...

		Light.	*Medium.*	*Heavy.*
		Per cent.	Per cent.	
B. — a) Fresh and clean fracture in the whole of the rail section . . .	with silvery oval mark . .	...	...	None.
	without silvery oval mark .	33.33	...	
b) Fracture, part of which is old and much rusted, extending to the outer surface of the foot or the head of the rail	in the foot	16.67	30	
	in the head	33.33	10	
c) Fracture, part of which is old and much rusted, not extending to the outer surface of the foot or the head of the rail. . . .	. . . .	16.67	60	

		2 pieces.	3 pieces.
d) Number of pieces into which the rail is broken	light	5	1
	medium	7	3
	heavy	...	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Eastern Railway. (*)		Miles.			Miles			Miles.			Miles.			Miles.		English tons
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	80.8	...	5	128.6	24.1	1	84.5	7.3	...	162.8	...	325	2 665 1	75.8	
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	2	445.5	2.8	7	375 3	11.6	7	223.7	19.4	27	436.2	38.4	120	1 218.5	61.2	18.3 (locomotives).
Heavy rails: of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	1	16.6	...	...	3 1	...	...	...	...	...	...	...	...	...	...	
Total. . .	3	543.1	3 4	12	507.0	14.7	8	308.2	16.1	27	599.0	28 2	445	3 883.6	71.2	

(*) Fractures in main lines, excluding points and crossings.

Number of train-miles : 36 225 734.
Total number of fractures : 495.

ber of fractures per 10 000 000 train-kilometres or 0 000 train-miles : 84.91.

	Percentage : Covered by the fishplates.
A. — Fractures of light rails	16.6
— medium	80.0
— heavy	... (1)

	Percentage : Clear of the fishplates.
A. — Fractures of light rails	83.4
— medium	20.0
— heavy	... (1)

		Light.	*Medium.*	*Heavy*
		Per cent.	Per cent.	
B. — a) Fresh and clean fracture in the whole of the rail section	with silvery oval mark	21.9	14.2	
	without silvery oval mark	39.8	33.5	
b) Fracture, part of which is old and much rusted, extending to the outer surface of the foot or the head of the rail	in the foot	20.1	13.3	None (1)
	in the head	11.9	15.9	
c, Fracture, part of which is old and much rusted, not extending to the outer surface of the foot or the head of the rail	in the web	6.3	23.1	

(1) Only one 55 kgr. (110.87 lb. per yard) rail broken at the joint.

		2 pieces.	3 pieces	4 pieces.	6 pieces.	9 pieces.
d) number of pieces into which the rail is broken	light	308	17	4	1	1
	medium	144	15	4	...	...
	heavy	1	...	...	...	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Midi Railway. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	4	...	...	...	...	...	60	...	5	269	11	57	2 103	17	17.7
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	1	402	2	19	461	25	4	93	26	...	...	...	...	...	...	17.7
Heavy rails: of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	17.7
Total.	1	406	2	19	461	25	4	153	16	5	269	11	57	2 103	17	...

(*) Main lines.

Number of train-miles : 20 009 083.
Total number of fractures : 86.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 27.

	Percentage : Covered by the fishplates
A. — Fractures of light rails	34
— medium	96
— heavy	...

	Percentage : Clear of the fishplates.
A. — Fractures of light rails	66
— medium	4
— heavy	...

		Light.	*Medium.*	*Heavy.*
		Per cent.	Per cent.	
B. — *a*) Fresh and clean fracture in the whole of the rail section.	with silvery oval mark	14.5	4.2	None.
	without silvery oval mark	22.6	4.2	
b) Fracture, part of which is old and much rusted, extending to the outer surface of the foot or the head of the rail	in the foot.	14.5	37 5	
	in the head	24.2	29.1	
c) Fracture, part of which is old and much rusted, not extending to the outer surface of the foot or the head of the rail		24.2	25.0	

		2 pieces.	3 pieces.	4 pieces.	6 pieces.	9 pieces.	11 pieces.	18 pieces.
d) Number of pieces into which the rail is broken	light.	50	3	6	1	1	1	1
	medium	19	2	2	1	...	...	...
	heavy	...	...	...	...	...	...	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			Maximum axle load.
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Northern Railway.		Miles			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre, or 85 lb. per yard.	0	0	0	2	307.58	4.04	4	45.36	54.8	1	34.18	18.2	104	837.00	77.2	18.5
Medium rails : of 42.5 to 52.5 kgr. per metre. (85 to 105 lb. per yard).	2	540.60	2.3	9	359.78	15.5	4	511.85	4.06	12	393.34	19.0	34	890.44	23.7	18.5
Heavy rails : of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	0	1.80	0	0	0.56	0	0	0.050	0	0	0	0	0	0	0	18.5
Total . . .	2	542.40	2.3	11	667.92	10.2	8	587.71	8.5	13	427.52	18.9	138	1 727.44	49.6	...

Number of train-miles : 31 378 333.

Total number of fractures : 172.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 30.

	Percentage : Covered by the fishplates.
A. — Fractures of light rails	28.0
— medium	68.8
— heavy	...

	Percentage : Clear of the fishplates.
A. — Fractures of light rails	72.0
— medium	31.2
— heavy	...

		Light.	Medium.	Heavy.
		Per cent.	Per cent.	
B. — a) Fresh and clean fracture in the whole of the rail section	with silvery oval mark	10.8	6.5	None.
	without silvery oval mark	28.0	4.9	
b) Fracture, part of which is old and much rusted, extending to the outer surface of the foot or the head of the rail	in the foot	31.5	27.9	
	in the head	16.2	23.0	
c) Fracture part of which is old and much rusted, not extending to the outer surface of the foot or the head of the rail	in the web	13.5	37.7	

		2 pieces.	3 pieces.	4 pieces.	5 pieces.	6 pieces.	21 pieces.
d) Number of pieces into which the rail is broken	light	100	8	1	1	0	1
	medium	31	7	2	0	1	0
	heavy	0	0	0	0	0	0

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Age of rails :					Length of single track.	Number of fractures per 1000 km. or per 625 miles.	Maximum axle load.
	Less than 5 years.	5 to 10 years.	10 to 20 years.	15 to 20 years.	More than 20 years.			
1	2	3	4	5	6	7	8	9
Orleans Railway. (*)						Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	2	...	4	...	37	4 143	6.4	18.7
Medium rails : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	9	15	3	11	82	2 499	29.8	18.7
Heavy rails : of a weight equal to or greater than 53 kgr. per m. of 106 lb. per yard.	...	...	...	...	...	52	...	18.7
Total . .	11	15	7	11	119	...	...	...

(*) On main lines only.

Number of train-miles : 38 797 374.
Total number of fractures : 163.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles ; 26.

	Percentage : Covered by the fishplates.		Percentage : Clear of the fishplates.
A. — Fractures of light rails	27.9	A. Fractures of light rails	72.1
— medium	50.0	— medium	50.0
— heavy	...	— heavy	...

		Light.	Medium.	Heavy.
		Per cent.	Per cent.	
B. — a) Fresh and clean fracture in the whole of the rail section	with silvery oval mark	18.6	30.0	None.
	without silvery oval mark	46.5	28.3	
b) Fracture, part of which is old and much rusted, extending to the outer surface of the foot or the head of the rail	in the foot	2.3	7.5	
	in the head	16.3	12.5	
c) Fracture, part of which is old and much rusted, not extending to the outer surface of the foot or the head of the rail	in the web	16.3	21.7	

		2 pieces.	3 pieces.	4 pieces.	5 pieces.	6 pieces.	13 pieces.
d) Number of pieces into which the rail is broken	light	39	2	...	...	1	1
	medium	98	15	5	1	1	...
	heavy	...	...	...	...	...	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load.*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Paris, Lyons and Mediterranean Railway. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight of 42.5 kgr. per m. (85 lb. per yard).	1	234	2.65	...	67	...	1	192	3.24	9	290	19.32	303	3 698	50.90	18.2
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	10	783	7.93	21	339 (1)	38.53	36	1 000	22.86	59	1 190	30.80	203	1 441	87.53	
Heavy rails: of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	2	19	66 66	...	...	...	...	...	...	...	...	...	...	...		
Total. . .	13	1 036	7.19	21	406 (2)	32.15	37	1 192	19.28	68	1 480	28.55	506	5 139	61.17	

(*) Broken rails, excluding those in points and crossings.

Number of train-miles : 67 744 637.
Total number of fractures : 645.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 59. 16.

(1) 16 of these in tunnels on 20.8 miles of single line, that is a proportion of 477.61 per 1 000 km. or 625 miles, the proportion of 38.53 being reduced to 9.77 outside tunnels.

(2) 16 of these in tunnels on 24.2 miles of single line, that is a proportion of 410.25 per 1 000 km. or 625 miles, the proportion of 32.15 being reduced to 8.14 outside tunnels.

PARIS, LYONS AND MEDITERRANEAN RAILWAY.

Table 1.

	Fractures covered by the fishplates.		Fractures clear of the fishplates.	
	Number.	Percentage.	Number.	Percentage.
Light rails	94	29.33	220	70.07
Medium —	253	76.90	76	23.10
Heavy —	2	100.00	...	...

Table 2

	Fresh and clean fractures through the whole of the rail section.		Fractures partly old.	
	Number.	Percentage.	Number.	Percentage.
Light rails	170	54.14	144	45.86
Medium —	153	46.50	176	53.50
Heavy —	1	50.00	1	50.00

Table 3.

	Rails broken into :													
	2 pieces.		3 pieces.		4 pieces.		5 pieces.		6 pieces.		7 pieces.		8 and more.	
	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.
Light rails	260	82.80	33	10 50	11	3.51	7	2.22	1	0.32	"	"	2	0.65
Medium —	250	75.98	53	16.11	16	4.86	5	1.52	1	0.31	1	0.31	3	0.91
Heavy —	2	100.00	...	...	...	...	...	...	...	...	...	...	...	...

Table 4.

	Fresh and clean fractures through the whole of the rail section.				Fractures with old part extending to the outer surface				Fractures with much rusted old part not extending to the outer surface of the foot or the head.	
	With oval mark.		Without oval mark.		of the foot.		of the head.			
	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.
Light rails	27	8.60	143	45.54	52	16.56	29	9.24	63	20.06
Medium —	19	5.78	134	40.72	42	12.77	24	7.29	110	33 44
Heavy —	...	...	1	50.00	...	...	1	50.00	...	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years			*Maximum axle load.*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Cambrésis Railway. (Cambrai to Catillon and Denain to Catelet and St-Quentin lines).					Miles.			Miles						Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	28.0	...	...	12.1	...	...	...	17 (1)		9.3	1 133	6.9
												11 (2)		21.1	324	
Number of train-miles : 263 470. Total number of fractures : 28.	Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 660.															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Bouches-du-Rhône Departmental Railways and Electric Tramways.														Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	7	123.303	35.2	14.8
Number of train-miles : 249 829. Total number of fractures : 7.	Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 174.106															

(1) 18 kgr. (36.28 lb. per yard) rails. — (2) 20 kgr. (40.31 lb. per yard) rails.

1	2	3	4	5	6		8	9	10	11	12	13	14	15	16	17
Tarn Departmental Railways.														Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre, or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	0	93	0	7.9
Eastern of Lyons Railway.		Miles.												Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	4.3	...	...	...	...	...	...	...	...	...	...	12	68	109	14.8

Number of train-miles : 277 660.

Total number of fractures : 12.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 268.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Light Railways of the Landes.														Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	9	226	24.7	14.3

Number of train-miles : 357 972.

Total number of fractures : 9.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 156.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails : Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9,	10	11	12	13	14	15	16	17
Somain-Anzin-Frontière belge Railway.											Miles.			Miles.		
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	1	21.410	29	3	27.374	68	...

Number of train-miles : 459 800
Total number of fractures : 4.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 34.

Provence Railway.

Broken rails are almost unknown on this system.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Ain Departmental Tramways.											Miles.			Miles.		
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	5	110.6	28.08	11	112.5	60.77	...
										1	21.7	314.28				

United Transport Company for Paris and district

As staded in 1926 and 1927, this Company keeps no records of broken rails.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ALGERIA AND TUNIS.								Miles.						Miles.		English tons.
Algerian State Railways.																
Algiers District.																
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	12	697	10.704	13.8
Medium rails :																
of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	...	...	...	...	...	...	...	186	...	...	...	...	...	...	...	13.8

Number of train-miles : 3 858 208.

Total number of fractures : 12.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 19.326.

A. — Percentage of fractures in the respective portions of the rails :

1. Covered by the fishplates . . . . 41 %
2. Clear of the fishplates . . . . 59 %

B. — Fractures according to the appearance of the fracture :

a) Fresh and clean fracture through the whole of the rail section :

1. With silvery oval mark . . . . 16 %
2. Without silvery oval mark . . . . 34 %

b) Fractures, part of which are old and much rusted, extending to the outer face of the foot or head of the rail :

1. Rusted part in the foot. . . . . 25 %
2. Rusted part in the head . . . . 25 %

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail . . . . 0 %

d) Number of pieces into which the rail is broken . . . 2 and 4

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails : Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Bône District.		Miles.			Miles.									Miles.		English tons.
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	4	182.7	13.60	13.8
Medium rails :																
of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	...	15.9	...	...	75.7	...	...	...	...	...	...	...	...	...	...	...

Number of train-miles : 1 534 000.
Total number of fractures : 4

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 16.202.

A. — Percentage of fractures in the respective portions of the rails :
1. Covered by the fishplates . . . . 25 %
2. Clear of the fishplates. . . . . 75 %

B. Fractures according to the appearance of the fracture :
a) Fresh and clean fracture through the whole of the rail section :
1. With silvery oval mark . . . . 75 % (blowholes)
2. Without silvery oval mark. . . . . 25 %

b) Fractures, part of which are old and much rusted extending to the outer face of the foot or head of the rail :
1. Rusted part in the foot . . . .
2. Rusted part in the head . . . .

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail. . . ...

d Number of pieces into which the rail is broken : 2 for each fracture.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Age of rails :				Maximum axle load
	Less than 5 years 5 to 10 years 10 to 15 years 15 to 20 years.	More than 20 years.			
		Number of fractures	Length of single track of this class	Number of fractures per 1 000 km. or per 625 miles	
1	2	3	4	5	6
			Miles		English tons.
Oran District. *Light rails :* of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	None.	18	822	13.6'5	10.38

Number of train-miles : 1 720 049.
Total number of fractures : 18.

Number of fractures per 10 000 000 train kilometres or 6 250 000 train-miles : 65.026.

A. — Percentage of fractures in the respective portions of the rails :

1. Covered by the fishplates . . . . 5.6 %.
2. Clear of the fishplates. . . . . 94.4 %.

B. — Fractures according to the appearance of the fracture :

a) Fresh and clean fracture through the whole of the rail section : 83.3 %.

1. With silvery oval mark . }
2. Without silvery oval mark } (this information cannot be supplied).

b) Fractures, part of which are old and much rusted, extending to the outer face of the foot or head of the rail :

1. Rusted part in the foot . . . . 16.7 %.
2. Rusted part in the head. . . . . 0 %.

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail . . . .

d) Number of pieces into which the rail is broken : 2 pieces for each rail.

Names of administrations and description of rails	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years			Maximum axle load
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Paris, Lyons and Mediterranean Railway (Algerian system).		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	100.0	...	2	96.3	12.90	2	111.8	11.11	1	124.3	5	15	310.7	30	16.39
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	...	37.9	...	...	7.5	...	...	...	...	...	...	...	...	...	...	16.39
Heavy rails: of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	...	1.2	...	...	...	...	...	...	...	...	...	...	...	...	30	16.39
Total. . .	...	139.1	...	2	103.8	12.90	2	111.8	11.11	1	124.3	5	15	310.7	30	...

Number of train-miles : 2 347 109.
Total number of fractures : 20.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 52.94.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Gafsa Railway.														Miles.		English tons.
Light rails: of a weight less than 42 5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	6	151	24.69	9.8

Number of train-miles : 1 043 533.
Number of train-miles since the line was open 29 years ago : 16 107 940.
Total number of fractures : 6.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : about 36.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails : Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tunisian Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.																
20 kgr. (40.32 lb. per yard) (narrow gauge)	...	145.66	...	...	145.66	...	...	145.66	...	...	145.66	...	9	145.66	38.393	11.8
25 kgr. (50.40 lb. per yard) (standard gauge) . .	...	4.57	...	...	4.57	...	...	4.57	...	...	4.57	...	4	4.57	544.436	14.8
25 kgr. (50.40 lb. per yard) (narrow gauge). . . .	1	364.41	1.705	...	364.41	...	...	364.41	...	14	364.41	23.872	19	364.41	32.398	11.8
30 kgr. (60.48 lb. per yard) (standard gauge) . . .	...	152 44	...	...	152.44	...	...	152.44	...	2	152.44	8.152	1	152.44	4.076	14.8
30 kgr. (60.48 lb. per yard.) (narrow gauge). . . .	...	158.27	...	...	158.27	...	...	158.27	..	...	158.27	...	...	158.27	...	11.8
34 kgr. (68.54 lb. per yard) (standard gauge) . . .	...	29.99	...	...	29.99	...	...	29.99	...	...	29.99	...	6	29.99	124.319	14.8
38.20 kgr. (77.01 lb. per yard) (standard gauge) . .	...	107.51	...	...	107.51	...	...	107.51	...	...	107.51	...	...	107.51	...	14.8
Medium rails :																
of 42.5 to 52.5 kgr. per m (85 to 105 lb. per yard)																
46 kgr. (94.21 lb per yard) (standard gauge) . . .	...	20.84	...	...	20.84	...	...	20.84	...	...	20.84	...	...	20.81	...	14.8
Heavy rails :																
of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.																
None.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total. . .	1	983.69	0.6316	...	983.69	...	...	983.69	...	16	983.69	10.107	39	983.69	24.5358	...

Number of train-miles : 3 247 177.
Total number of fractures : 56.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 107.162.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 20 years. Number of fractures.	5 to 20 years. Length of single track of this class.	5 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	FRACTURES: Covered by the fishplates. Number.	Covered by the fishplates. Percentage.	Clear of the fishplates. Number	Clear of the fishplates. Percentage.	APPEARANCE OF THE FRACTURES: Fresh and clean fracture in the whole of the rail section. with silvery oval mark.	Fresh and clean fracture in the whole of the rail section. without silvery oval mark.	Fracture, part of which is old and much rusted: extending to the outer surface of the foot or the head of the rail. RUSTED PART in the foot. Number	extending … in the foot. Percentage.	extending … in the head. Number	extending … in the head. Percentage.	not extending to the outer surface of the foot or the head of the rail. Number	not extending … Percentage.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
COLONIES AND PROTECTORATES.																					
AFRICA.																					
French West African Railways.																					
a) Thiès to the Niger.																					
Flat, 20 kgr. (40.32 lb. per yard), 6 m. (19 ft. 8 1/4 in.) long.	...	...	...	...	...	...	23	360	39.65	2	8.69	21	91.31	0	0	15	65.21	5	21.74	3	13.05
Flat, 25 kgr. (50.40 lb. per yard), 8 m. (26 ft. 3 in.) long.	...	...	...	...	...	...	1	435	0.70	0	0	1	100	0	0	1	100	0	0	0	0
Flat, 26 kgr. (52.41 lb. per yard).	...	...	...	...	...	...	0	16	...	...	...	...	...	...	...	...	...	...	...	...	...
Total.	...	...	...	...	...	...	24	811	18.60	2	8.33	22	91.66	0	0	16	66.67	5	20.83	3	12.50

Maximum axle load : 9.8 English tons.

Number of train-miles : 1 243 398.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 119.93.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails : Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
b) **Conakry to the Niger Railway.**																English tons.
25 kgr. per m. (50.40 lb. per yard) rails. . .	...	...	...	...	...	...	1	75	8.33	...	...	..	...	...	...	9.8

Number of train-miles : 327 965.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 18.94.

c) **Dahomey Railways.**	No fractured rails in 1927.	
French Dahomey Railway Company.	No fractured rails in 1927.	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Reunion Island Railway.														Miles.		English tons.
Light rails : of a weight less than 12.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	18	21.7	511	5.9

Number of train-miles : 646 300.
Total number of fractures : 18.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 17.30.

Names of administrations and description of rails	Less than 5 years: Number of fractures.	Less than 5 years: Length of single track of this class.	Less than 5 years: Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years: Number of fractures.	5 to 10 years: Length of single track of this class.	5 to 10 years: Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years: Number of fractures	10 to 15 years: Length of single track of this class.	10 to 15 years: Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years: Number of fractures.	15 to 20 years: Length of single track of this class.	15 to 20 years: Number of fractures per 1 000 km. or per 625 miles.	More than 20 years: Number of fractures.	More than 20 years: Length of single track of this class.	More than 20 years: Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ASIA MINOR.																
Damas-Hamah and Extensions Railway.														Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	7 (1) 3 (2)	91.22 206.02	20.8 ...	12.48 12.99
Total. . .													10	297.24	20.8	..

Number of train-miles : Beyrouth-Damas : 509 057. Rayak-Halep : 189 766.
Total number of fractures : 10 of which 3 new breakages and 7 with old rusted part.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 85.8.

(1) Narrow gauge : Beyrouth-Damas line, 27.620 kgr. (55.68 lb. per yard). — (2) Standard gauge ; Rayak-Halep line, 30 kgr. (60.48 lb. per yard).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Smyrne-Cassaba and Extension Railway.		Miles.						Miles.			Miles.			Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	25	...	...	...	...	...	127	...	...	25	...	...	258	...	14.27

Number of train-miles ; 549.237.
Total number of fractures : 0.

Number of fractures per 10 000 000 train-kilometres or 250 000 train-miles : 0.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
INDO-CHINA.																
Indo-Chinese Colonial Railways.								Miles.			Miles.			Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	1 (1)	171.5	4	0	63.4	0	2 (2)	371.0	3	9.8

Number of train-miles : 1 954 806.
Total number of fractures : 3.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 9.

(1) Fresh and clean fracture in the whole of the rail section without silvery oval mark. — (2) Fresh and clean fracture in the whole of the rail section with silvery oval mark ; fracture, part of which is old and much rusted, extending to the outer surface of the foot or the head of the rail.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ndo-China & Yunnan Railways.											Miles.					English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	14 broken. 53 cracked.	534	16 broken. 62 cracked.	...	...	...	9.8

Number of train-miles : 1 744 867.
Total number of fractures : 14 rails broken; 53 cracked

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 57 fractures; 220 cracks.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
GREAT BRITAIN AND NORTH OF IRELAND. Great Western Railway.																English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	1	...	...	3	...	...	14
Medium rails : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	2	...	...	5	...	...	3	...	...	4	...	...	11	...	...	22.5

Number of train-miles : 63 899 161.
Total number of fractures : 32.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 3.13.

The above statement shews the number of rail breakages which occurred in main running lines (as distinct from sidings) in this Company's system.

No statistics for completing the columns headed « Length of single track » of each weight and age of rail are available.

PARTICULARS OF THE FRACTURES.

A. — Percentage of breakages in respective portions of rails covered by and clear of the fishplates :

Covered by fishplates : 17 = 53.1 %.
Clear of fishplates : 15 = 46.9 %.

B. — Percentage of fractures according to the appearance of the fracture :

a) Fresh and clean through the whole of the rail section : 6 = 18.8 %.
1. With silvery oval mark : 1 = 3.1 %
2. Without silvery oval mark : 5 = 15.7 %

b) Fractures, part of which are old and much rusted, extending to the outer face of the foot or head of the rail :
1. Rusted part in the foot : 1 = 3.1 %.
2. Rusted part in the head : 16 = 50.0 %.

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail : 9 = 28.1 %.

d) Number of pieces into which the rail was broken :
2 pieces : 25 = 78.1 %, 3 pieces : 4 = 12.5 %, 4 pieces : 3 = 9.4 %.

Note. — Compiled on full section rails only. A fracture is considered to be a complete break through the rail, or a complete interruption of the top flange. Wing rails of crossings and stock rails of points are not included.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
London Midland and Scottish Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	...	1 222	...	...
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	1	2 040	0.31	4	1 701	1.47	11	1 480	4.64	13	1 946	4.17	17	4 971	2.14	20.9

Number of train-miles : 149 102 605.
Total number of fractures : 46.
Running lines reduced to single track : 13 360 miles taken from statistical return — Sidings not included.
The total of fractures does not include those on goods lines.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 1.93.

PARTICULARS OF THE FRACTURES.

A. — Percentage of breakages in respective portions of the rails covered by and clear of fishplates.
Clear of fishplates : 30=65.2 %. — Covered by fishplates : 16=34.8 %.

B. — Percentage of fractures according to the appearance of the fracture.

a) Fresh and clean fracture through the whole of the rail section : 29 = 63 %;

b) Fractures part of which are old and much rusted extending to the outer face of the foot or head of the rail.

1. Rusted part in the foot : 9 = 19.5 %;
2. Rusted part in the head ; 7 = 15.2 %.

Four cases both foot and head.

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail : 1 = 2 %.

d) The number of pieces into which the rail is broken

2 pieces :	33 =	72 %.
3 —	2 =	4 %.
4 —	11 =	24 %.
	46 =	100 %.

The above is compiled on full section rails only. A fracture is considered to be an entire separation from top to bottom (or a complete interruption of the top flange).
Cranked or bent rails are not included when broken at the bend. Wing rails of crossings are included when the fracture is not at the bend.
Side or stock rails of points are included.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
London and North Eastern Railway. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	38.96	...	...	40.84	...	...	99.57	...	...	132.06	...	5	1 692.90	1.85	20
Medium rails : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	9	1 741.74	3.22	12	1 029.46	7.29	10	1 597.30	3.91	8	1 442.45	3.47	13	2 655.05	3.06	22.5
Total. . .	9	1 780.70	3.16	12	1 070.30	7.01	10	1 696.87	3.68	8	1 574.51	3.18	18	4 347.95	2.59	...

(*) In running lines, year 1926.

Number of train-miles : 86 999 584.
Total number of fractures : 57.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 4.09.

Rails are broken when : *a*) completely severed from top to bottom ; *b*) also when a piece of the head is broken away leaving a gap in the running surface. — ***Broken rails in sidings not included.***

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
London and North Eastern Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	38.97	...	...	40.84	...	...	98.48	...	...	130.97	...	6	1 658.80	2.26	20
Medium rails : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	4	1 776.59	1.41	6	1 060.33	3.54	6	1 482.82	2.52	10	1 438.30	4.34	12	2 784.73	2.69	22.5
Total. . .	4	1 815.66	1.37	6	1 101.17	3.40	6	1 581.30	2.37	10	1 569.27	3.98	18	4 443.53	2.53	...

Number of train-miles : 105 177 791.
Total number of fractures : 44.

Number of fractures per 10 000 000 train-kilometres
6 250 000 train-miles : 2.61.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Southern Railway.		Miles.						Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	2	23	54.348	14	204	42.892	...
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	6	779	4.814	10	765	8.17	8	352	14.205	6	815	4.601	5	1.205	2.593	20.65
Total. . .	6	779	4.814	10	765	8.17	8	352	14.205	8	838	5.967	19	1.409	8.428	...

Number of train-miles : 54 915 625.
Total number of fractures : 51.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 5.804.

A. — Percentage of breakages in the respective portions of the rails covered by and clear of the fishplates:

Breakages covered by fishplates : 16 = 31.37 %.
Breakages clear of fishplates : 35 = 68.63 %.

B. — The number of pieces into which the rail is broken:
2 pieces : 38.
3 — 7.
4 — 5.
6 — 1.

Information in regard to percentage of fractures according to the appearance of the fracture *i. e.* with and without silvery oval mark, rusted portions, etc., is not available for 1927, but will be kept for the 1928 return.

Cheshire Lines Committee.	No broken rails in 1927.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Great Northern Railway (Ireland). (*)														Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	9	163.294	34.44	18

(*) In passenger lines.

Number of train-miles : 3 807 681.

Total number of **fractures** : 9.

Number of *fractures* per 10 000 000 **train-kilometres** or 6 250 000 train-miles : 14.772.

A. — **Percentage of breakages** in the respective portions of the rails :

1. Covered by the fishplates . . . . **44.44 %**
2. Clear of the fishplates . . . . 55.56 %

B. — **Percentage** according to the appearance of the fracture :

a) **Fresh and clean fracture through the whole of the rail** section : 44.44 %

1. With silvery oval mark . . . . Nil.
2. Without silvery oval mark . . . . Nil.

b) Fractures, **part** of which are old and much rusted, **extending** to the outer face **of the** foot or head of the **rails** :

1. Rusted part in the foot . . . . 44.44 %
2. Rusted part in the head . . . . Nil.

c) Fractures **with** much rusted portions not **extending** to the **outer** face of the foot or head of the **rail** . . . . 11.12 %

d) **Number** of pieces into which **the rail** is broken : 8 rails into **2** pieces, 1 rail into 3 pieces.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Metropolitan Railway (London.)		Miles.			Miles			Miles.			Miles.			Miles.		English tons.
Medium rails : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	1	23.025	...	1	15.100	...	...	18.825	...	1	3.650	...	...	14.050	...	20

Number of train-miles : 5 125 699.
Total number of fractures : 3.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			Maximum axle load.
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Underground Electric Railways Company of London (Metropolitan District and Tube Railways).		Miles.						Miles.			Miles.					English tons.
Medium rails: of 42.5 to 52.5 kgr. per metre (85 lb. per yard).	2	54.50	22.93													
	(Metropolitan District.)															
	1 [1]	104.70	5.96	...	...	...	...	...	...	5	104.70	29.84	...	...	...	Met. Dist.: 11.25 Tube Rys: 11.50
	(Tube Railways.)									(Tube Railways.)						

(1) Due to electrical burning.

Number of train-miles: Metropolitan District: 4 600 000.

— — Tube Railways: 13 000 000.

Total number of fractures: Metropolitan District: 2.

— — Tube Railways: 6.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles:

Metropolitan District . 2.72.

Tube Railways: 2.88.

County Donegal Railways Joint Committee.	No case of fractured rails in 1927.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Great Central and Midland Joint Committee. (*)											Miles.					English tons.
Medium rails : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	...	...	...	...	...	...	...	...	...	1	36.96	16.95	...	...	...	20

(*) In running lines.

Number of train-miles : 710 028.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 8.80

Rails are broken when ; *a*) completely severed from top to bottom ; *b*) also when a piece of the head is broken away leaving a gap in the running surface. — **Broken rails in sidings not included.**

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
London Midland and Scottish Railway (Northern Counties Committee), Ireland.														Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	10	223	28	17.5

Number of train-miles : 1 604 857.
Total number of fractures : 10.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 39.

A. — Percentage of breakages in the portion of the rails covered by the fishplates : 80 %.

B. — Percentage of fractures according to the appearance of the fracture :

a) Fresh and clean fracture through the whole of the rail section :

Without silvery oval mark : 20 %

b) Fractures, part of which are old and much rusted, extending to the outer face of the foot or head of the rail :

1° Rusted part in the foot : 10 %.
2° Rusted part in the head : 10 %.

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail : 60 %.

d) Number of pieces into which the rail is broken : 80 % in 2 pieces, and 20 % in 3 pieces.

Midland and Great Northern Railways Joint Committee.	No fractured rails in 1927.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	SECTION OF LINE.	NUMBER OF FRACTURES AND PARTICULARS OF T													
		AGE OF RAILS :													
		Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20	
		Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			Miles.												
INDIA, DOMINIONS, PROTECTORATES AND COLONIES. — **AFRICA.** **Beira and Mashonaland and Rhodesia Railways.**															
	Beira-Villa Machado. . .	...	...		...	...	...	...	...	...	...	...		...	61
	Villa Machado-Umtali . .	...	48 3/4		...	...	...	...	...	...	...	...		1	94 1/2
	Umtali-Salisbury.	...	...		...	...	...	...	...	...	...	...		1	170
	Salisbury-Bulawayo . . .	...	...		...	...	...	...	...	...	...	...		19	295 3/4
	Bulawayo-Livingstone. .	...	...		...	80	...	...	...	...	...	...		16	206 3/4
	Livingstone-Broken-Hill.	...	...		...	...	...	...	...	...	...	...		20	368
Light rails :	Broken Hill-C. Border. .	...	...		...	...	...	...	...	...	9	132		...	...
weighing under 85 lb. per yard.	Selukwe Branch	1	23 1/4	Not expressed.	...	...	...	...	...	...	...	...	Not expressed.	...	...
	West Nicholson Branch .	...	...		...	...	...	...	...	...	...	...		2	102 3/4
	Lomagundi Branch. . . .	...	...		...	...	...	...	...	...	...	3 3/4		...	78 3/4
	Blinkwater Branch. . . .	...	...		...	...	...	...	...	...	...	123 1/2		...	...
	Mazoe Branch	...	...		...	...	...	...	...	...	1	73		...	...
	Total. . .	1	72	...	...	80	...	...	...	...	10	332 1/4	...	59	1377 1/2

Number of train-miles : 4 062 809. — Total number of fractures : 70.

Notes : The above information is given section by section and corresponding roughly to the locomotive running sections, giving the train-

RAILWAY.				Classification according to part II of suggestions adopted at the General Meeting of the London Congress in 1925.					
				A Percentage of fractures in respective portions of the rails covered by and clear of the fishplates.		B Percentage of fractures according to the appearance of the fracture :			
	Maximum axle load (engines).	Maximum speed of trains permitted.	REMARKS.	a) Percentage covered by fishplates.	b) Percentage clear of fishplates.	a) Fresh and clean fracture through whole of rail section.	b) Fractures part of which are old and much rusted extending to outer face of foot or head of rail.	c) Fractures with much rusted portions not extending to outer face of foot or head of rail.	d) Number of pieces into which rail is broken.
	19	20	21	22	23	24	25	26	27
	Tons. Cwt.	Miles per hour.							
928	9 12	30	41 3/4 miles relaid during 1927.	...	...	...	...	...	Every rail was broken in two parts only.
330	12 18	30	...	...	100.00	...	...	100.00	
41	13 00	35	...	100.00	...	...	100.00	...	
92	13 00	35	...	31.58	68.42	5.26	84.22	10.52	
46	13 00	35	...	50.00	5.00	18.75	68.75	12 50	
91	13 00	35	...	30.00	70.00	15.00	85.00	...	
33	12 18	35	...	11.11	88.89	77.78	22 22	...	
27	9 12	25	Engines of 13 tons axle load run occasionally on this branch.	100.00	...	...	100.00	...	
37	12 01	30	Engines of 13 tons axle load permitted at speed of 20 miles per hour.	...	100.00	...	100.00	...	
8	9 12	35	Engines of 12 tons 18 cwt. axle load permitted at speed of 25 miles per hour.	...	...	...	...	...	
7	12 01	30	Engines of 13 tons axle load permitted at 25 miles per hour.	...	...	...	...	...	
9	9 12	30	Engines of 12 tons 18 cwt. axle load permitted at 25 miles per hour.	...	100.00	...	100.00	...	
	...	...	...	37.86	67.14	20.00	72.86	7.14	...

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : not expressed.

ximum axle load in every case. — Trucks with axle loads of 13 tons 18 cwt. when loaded to full capacity run over all sections of the line.

Names of administrations and description of rails	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
Gold Coast Government Railways.	No cases of broken rails in 1927.															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Kenya and Uganda Railways and Harbours.		Miles.												Miles.		
Light rails:																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	2	391	3.18	...	...	...	...	...	...	...	...	...	14	775	11.23	...

Number of train-miles : 3 152 983.
Total number of fractures : 16

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 32.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Nigerian Railway.		Miles.						Miles.			Miles.			Miles.		English tons.
Light rails:																
30 lb. per yard	...	...	...	...	...	...	2	133	9.40	...	...	...	...	...	...	6.0
45 lb. —	...	...	...	...	...	...	...	...	...	5	513	6.09	...	...	...	9.5
55 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	1	246	2.51	12.5
60 lb. —	17	569	15.48	...	...	...	...	...	...	...	...	...	...	...	...	12.5
80 lb. —	1	128	4.88	...	...	...	...	...	...	...	...	...	...	...	...	16.5

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	*Light rails* : of 17.5 to 23 kgr. per metre (35 to 46 1/4 lb. per yard).	*Medium rails* : of 30 to 30.5 kgr. per metre (60 to 61 lb. per yard).	*Heavy rails* ; of 37.5 to 42.5 kgr. per metre (75 to 85 lb. per yard).
South African Railways and Harbours.			
Age of rails :			
Less than 5 years	1	23	15
5 to 10 years	...	1	8
10 to 15 years	2	22	87
15 to 20 years	11	15	59
Over 20 years	11	87	43
Age unknown (marks undecipherable)	34	158	11
Number of fractures	59	306	223
Length of single track (miles)	2 485	5 885	4 065
Number of fractures per 1 000 kilometres or 625 miles	14.84	32.50	34.29
Maximum axle load (English ton)	10.5	13.5	18.5
Total miles	12 435	...	...

Number of train-miles : 47 791 943.
Total number of fractures of all classes of rails : 588.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 76.94.

NOTE : The above fractures include those occurring in sidings as well as in running tracks.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Sudan Government Railways and Steamers.																
Light rails:																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...		...	...	...	.	...	...	...	...	...	..	33[1]	2 164.468	15.25	12.4
													2[2]	1 115.482	1.79	16

[1] 50 lb. per yard.
[2] 75 lb. per yard.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Number of fractures according to age of rails :						Length of running track of this class of rail.	Number of fractures per 1 000 km. or 625 miles.	*Maximum axle load.*
	0 to 5 years.	5 to 10 years.	10 to 15 years.	15 to 20 years.	Over 20 years.	Total.			
1	2	3	4	5	6	7	8	9	10
							Miles.		English tons.
Asia.									
CEYLON.									
Ceylon Government Railway.									
Light rails :									
46 1/4 lb. per yard.	...	...	...	...	1	1	352.3	12.2	9
72 and 80 lb. per yard.	1	...	...	1	9	11	381.2		14
Medium rails :									
88 and 90 lb. per yard.	...	1	1	...	...	2	232.4	5.4	16
Total. . .	1	1	1	1	10	14	965.9	9	...

Number of train-miles (including rails motors) : 4 382 334.2.
Total number of fractures : 14.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 19.

Names of administrations and description of rails	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
INDIA.																
Bengal Nagpur Railway (*)																
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	4	85.54	29.23	3	38.23	49.04	4	222.47	11.24	2	387.56	3.23	6	928.11	4.04	17.25
Medium rails :																
of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard.)	4	207.07	12.71	...	12.62	.	3	23.17	80.92	4	3.88	644.33	6	1 185.91	3.16	
Total. . .	8	292.61	17.09	3	50.85	36.87	7	245.64	17.81	6	391.41	9.58	12	2 114.02	3.55	

(*) Year 1927-1928.

Number of train-miles : 13 610 158.
Total number of fractures : 36.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 16.53.

Bengal and North Western Railway. (*)	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.						Miles.			Miles.			Miles.		
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	306.14	...	...	...	...	...	123.28	...	...	197.22	...	24	1 460.02	10.27	...

(*) Year 1927-1928.

Number of train-miles . 7 062 816.
Total number of fractures : 24.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 21.24

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Bombay, Baroda and Central India Railway. (Broad gauge.)		Miles:			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	1	804.928	0.78	3	804.928	2.33	6	504.928	4.66	17.5
Medium rails :																
of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	3	1 112.787	1.68	2	1 112.787	1.12	4	1 112.787	2.25	6	1 112.787	3.37	...	...	...	18.0
Total. . .	3	1 112.787	1.68	2	1 112 787	1.12	5	1 917.715	1.56	9	1 917.715	2.92	6	804.928	4.66	...

Number of train-miles on the whole of the broad gauge system for the year ending 31 December 1927 : 8 019 596.

Total number of fractures during the year ending 31 December 1927 : 25.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 19.48.

Note. — It is not possible to give percentage of fractures in the respective portions of the rails covered by and clear of the fishplates; percentage of fractures according to the appearance of the fracture is not available.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			Maximum axle load
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Bombay, Baroda and Central India Railway. Metre (3 ft. 3 ⅜ in.) gauge system.														Miles.		English tons.
Light rails : of a weight of :																
41 ¼ lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	(1) 12	1 215.94	6.17	8
50 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	(2) 24	1 331.00	11.27	10
60 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	...	305.69	...	10.5
Total.	...	...	...	...	...	...	...	...	...	...	...	...	36	2 852.63	7.84	...

Number of train-miles : 9 625 000.
Total number of fractures : 36.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 23.38.

(1) All fractures were outside the portion covered by the fishplates.

(2) 4 fractures or 16.7 % were inside the portion covered by the fishplates; the remaining 20 or 83.3 %, were outside the fishplates.

Note. — Percentage of fractures according to the appearance of the fracture is not available.

Burma Railway.	This Company, being taken over by the Government with effect from 1 January 1929, sent no information.

1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	17
Great Indian Peninsula Railway. (*)	Age of rails (from year of manufacture).															English tons.
Light rails :																
35 lb. per yard	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	7
62 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	13.5
68 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
69 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	14	...	...	13.5
75 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	4	...	...	16.5
80 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	24	...	...	15.5
82 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	11	...	...	18.6
Medium rails :																
85 lb. per yard	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	16.5
86 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
87 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
88 1/2 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
90 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
93 1/2 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
100 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

(*) Year ended 31 March 1927.

Number of train-miles : 23 204 430
Total number of fractures : 57.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 15.35.

—	RAILS OF :						
	35 lb.	62 lb.	69 lb.	75 lb.	80 lb.	82 lb.	85 lb.
Miles of railway including sidings	180.304	56.910	747.021	620.597	910.760	1 548.414	122.837

A) The above table shows the total mileage of each section of rails in use on the Great Indian and Peninsula Railway, and on which there were fractures. — B) It is not possible to give the total mileage according to age as no record exists, but no rails of the following sections were ordered or purchased for the last 20 years : 60, 62, 69, 75, 80, 85 and 87 lb. The last year of purchase of 82 lb. rails was 1923-1924.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Great Indian Peninsula Railway. (*)	Age of rails (from year of manufacture)															English tons.
Light rails :																
35 lb. per yard	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	7
62 lb. —	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	13.5
69 lb. —	...	...	...	...	...	...	4	...	...	1	...	...	10	...	...	13.5
75 lb. —	...	...	...	...	...	...	...	...	...	1	...	...	5	...	...	16.5
80 lb. —	...	...	...	...	...	...	2	...	...	1	...	...	29	...	...	17.5
82 lb. —	...	...	...	...	...	...	5	...	...	1	...	...	9	...	...	18.5
85 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	20
Medium rails :																
86 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	20
100 lb. —	...	...	...	3	...	...	3	...	...	...	...	...	...	...	...	20

(*) Year ended 31 December 1927.

Number of train-miles : 28 907 594.
Total number of fractures : 80

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 17.29.

RAILS OF :

—	35 lb.	62 lb.	69 lb.	75 lb.	80 lb.	82 lb.	85 lb.	86 lb.	100 lb.
Miles of railway including sidings.	180.304	56.910	747.021	620.597	910.760	1 548.414	122.837	28.014	1 207.727

A) The above table shows the total mileage of each section of rails in use on the Great Indian Peninsula Railway and on which there were fractures. — *B*) It is not possible to give the total mileage according to age as no record exists, but no rails of the following sections were ordered or purchased for the last 20 years : 60, 62, 69, 75, 80, 85, 86 and 87 lb. The last year of purchase of 82 lb. rails was 1923-1924.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Madras and Southern Mahratta Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails :																
Less than 85 lb. per yard.	...	434.785	...	...	151.245	...	1	194.750	3.21	2	372.75	3.35	31	1 660.87	11.67	17.95
Medium rails :																
of 42.5 to 52.5 kgr. per m. (85 to 105 lb. per yard).	1	174.75	3.58	...	105.875	...	...	...	...	...	...	...	...	...	...	17.95
Total . . .	1	609.535	1.03	...	257.120	...	1	194.750	3.21	2	372.75	3.35	31	1 660.87	11.67	...

Number of train-miles : 14 757 200.
Total number of fractures : 35.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 14.82.

CLASSIFICATION OF BREAKAGES.

	Total number of breakages.	A		B				
		Percentage of breakages.		Percentage of fractures as per appearance.				
				a) Fresh and clean		b) Fractures parts of which are old and much rusted.		c) Percentage of fractures with much rusted portions not extending to the outer face of foot or head.
		Covered by fishplate.	Clear of fishplate.	1. With silvery oval mark.	2. Without silvery oval mark.	1. Rusted part in the foot.	2. Rusted part in the head.	
Light rails	34	17.65	82.35	14.70	11.76	44.13	23.53	5.88
Medium rails	1	0	100	0	0	0	100	0

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
North Western Railway. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per m. or 85 lb. per yard.	0	208.07	0	0	353.8	0	1	529.27	1.18	4	446.87	5.59	20	3 306.40	3.78	17.0
Medium rails: of 42.5 to 52.5 kgr. per m. (85 to 105 lb. per yard).	4	415.75	6.01	1	541.13	1.15	2	389.38	3.21	6	576.0	6.51	0	542.49	0	18.0
Total. . .	4	623.82	...	1	894.93	...	3	918.65	...	10	1022.87	...	20	3 848.89	...	...

(*) Year ending 31 March 1928.

Number of train-miles : 26 039 633.
Total number of fractures : 38.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 9.12

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Rohilkund and Kumaon Railway.																English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	3	571.94	3.28	9.5

Number of train-miles : 1 432 006.
Total number of fractures : 3.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 13.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
South Indian Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	1	241.26	2.58	...	91.01	...	...	281.11	...	...	55.46	...	4	1 621.18	1.54	7.80 (1) 8.15 (2) 10.00 (3)
Medium rails: of 42.5 to 52.5 kgr. per m. (85 to 10 lb. per yard).	...	56.89	...	...	53.14	...	...	...	...	...	...	...	...	0.25	...	18

Number of train-miles : 9 577 699.
Total number of fractures : 5.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 3.21.

(1) For 35 lb. rails. — (2) For 40 and 41 1/4 lb. rails. — (3) For 50 to 75 lb. rails.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
														Miles.		English tons.
MALAY PENINSULA.																
Federated Malay States Railways.																
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	2	1 105	1.13	12

Number of train-miles : 4 692 205.
Total number of fractures : 2.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 2.66.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
AUSTRALASIA.																
New South Wales Government Railways.																
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	5 883	...	2	5 883	0.21	8	5 883	0.85	13	5 883	1.33	25	5 883	2.65	20.35
Medium rails :																
of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	...	629	...	1	629	0.99	4	629	3.97	1	629	0.99	...	629	...	20.35
Total. . .	...	6 512	...	3	6 512	0.28	12	6 512	1.15	14	6 512	1.34	25	6 512	2.399	...

Number of train-miles : 26 325 847.
Total number of fractures : 54.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 12.82.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
New Zealand Government Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	1	434	1.43	1	163	3.83	12	434	17.3	28	778	22.5	54	1 445	23.3	14

No fractures occurred during the year in any rails over 85 lb. per yard.
Number of train-miles : 10 850 000.
Total number of fractures : 96.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 55.
Number of fractures at joints : 60 = 62 °/. of total.
Number of fractures away from joints : 36 = 38 °/. of total.

PARTICULARS OF THE FRACTURES.		Number.	Percentage of total.
a) Fresh and clean fracture in the whole of the rail section.	with silvery oval mark.	...	...
	without silvery oval mark	3	3.01
b) Fracture, part of which is old and much rusted, extending to the outer surface of the foot or the head of the rail	in the foot	39	40.5
	in the head.	10	10.4
c) Fracture, part of which is old and much rusted, not extending to the outer surface of the foot or the head of the rail		44	46

IRISH FREE STATE County Donegal Railways Joint Committee. — Great Northern Railway.	(See under : « Great Britain & North of Ireland »).

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Age of rails :															Maximum axle load
	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years			37 years.			
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
GREECE. North Western Railway.														Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	1	38.5	16	8.3

Number of train-miles : 98 380.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 64.

1	2	3	4	5		7	8	9	10	11	12	13	14	15	16	17
Thessaly Railways.														Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	17	**More than 20 years.** 126	84.16	9.1

Number of train-miles : 261 332.
Total number of fractures : 17.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 404.22

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Rails in use for: Less than 5 years. Number of fractures.	5 to 10 years. Number of fractures.	10 to 20 years. Number of fractures.	20 to 30 years. Number of fractures.	More than 30 years. Number of fractures.	TOTAL.	Approximate length of the lines considered as single line.	Number of fractures per 1 000 km. or 625 miles	*Maximum axle load in service.*
1	2	3	4	5	6	7	8	9	10
ITALY. State Railways.							Miles.		
Light rails of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	10	21	52	114	977 (1)	1 174	8 596	84	16.2
Medium rails : of 42.5 kgr. per metre (85 lb. per yard)									
In tunnel	1	45	335	4	...	385	192	1 241 } 76	
In the open	1	11	51	9	...	72	3 500	12 }	16.7
Total.	2	56	386	13	...	457	3 692	...	...
Heavy rails : of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	...	...	...	...	...	...	...	...	...
Total general.	12	77	438	127	977	1 631	12 288	82	...

Number of train-miles : 89 945 100.
Total number of fractures : 1 631.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 112.

Note. — As we have already had occasion to remark when returning the figures for 1926, most of the fractures of rails have occurred in tunnels at the bolt holes. In order to cure as far as possible, this defect, due especially to the configuration of our lines and their special conditions, which make the maintenance of the joints very laborious and difficult, we are using at the joints themselves bearing plates with the object of making the joints more rigid and less sensitive to blows from tyres.

(1) Most of these rails were put into service more than forty years ago.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load.*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
Tessin Railways.	No rail fractures in 1927. Number of train-miles : 555 677.															
Società Trazione Elettrica Lombarda.	No rail fractures in 1927.															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
JAPAN.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Japanese Government Railways. (*)																
Light rails : of a weight less than 42.5 kgr per metre or 85 lb. per yard.	61	2 556.2	14.9	92	1 560.2	36.9	63	1 122.1	35.1	123	1 140.2	67.5	157	2 9:6 1	33.8	14.76

(*) Year 1926.

Number of train-miles : 96 355 894.
Total number of fractures : 509 (including 13 of unknown age).

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 33.1.

Note. — 32.8 % of the above fractures occurred in the part of the rail covered by the fishplates and 67.2 % in the part clear of the fishplates. (Information based on the statistics of breakages of rails for 1926).

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails : Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
LUXEMBURG Guillaume-Luxemburg Railways.	(See under « Alsace and Lorraine Railways ».)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Prince Henry Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	0	16.000	0	2	10.006	124.2	2	21.286	51.2	3	22.214	83.9	4	32.092	77.4	15.7
Medium rails :																
of 42.5 to 52.5 kgr. per metre (85 *to* 105 lb. per yard.)	0	20.225	.	0	4.680	0	0	8.812	0	...	...	...	...	...	...	15.7
Total. . .	0	36.225	0	2	14.686	84.6	2	33.128	37.5	3	22.214	83.9	4	32.092	77.4	...

Number of train-miles : 978 186.
Total number of fractures : 11.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 trains-miles : 70.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Length of single track of this class.	Age of rails : Less than 5 years.		5 to 10 years.		10 to 15 years.		15 to 20 years.		More than 20 years.		TOTAL		*Maximum axle load.*
		Number of fractures.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Per 1 000 km. or per 625 miles.	
	Miles.													Pounds.
NORWAY. State Railways. *Light rails.*	2 131	19	5.5	18	5.2	92	26.8	7	2.0	73	21.3	209	60.8	40 320

Number of train-miles : about 8.42 millions.

Total number of fractures : 209.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 154.

Classification of fractures :

A. — At the joint : 32 %.

B. — *a)* New clean break : 48 %.

b) With rusted part : 1. in the base : 41 % ; 2. in the head : 4 %.

c) With other oxidisation : 7 %.

d) Number of pieces of broken rail : 2 pieces : 97 % ; 3 pieces : 3 %.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
HOLLAND.																
Netherlands Railways.																
Light rails: of a weight less than 42.5 kgr. per m. or 85 lb. per yard.	2	159.1	8	12	343.0	24	20	454.8	28	21	646	21	167	927	112	15.7
Medium rails: of 42.5 to 52.5 kgr. per m. (85 to 105 lb. per yard).	3	154.1	12	8	252.3	20	2	281.5	4	1	14.9	40	...	55.9	...	19.7
Heavy rails: of a weight equal to or greater than 53 kgr. per metre or 106 lb. per yard.	The Company does not use heavy rails.															
Total . . .	5	...	...	20	...	...	22	...	...	22	...	...	167	...	...	...

Number of train-miles : 29 205 000.
Total number of fractures : 236.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 50.

	Light rails : of a weight less than 42.5 kgr. per m. or 85 lb. per yard.	*Medium rails* : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	
Netherlands Railways.			
A. — Percentage of fractures in the respective portions of the rails :			
a) Covered by the fishplates	57 %	85 %	
b) Clear of the fishplates	43 %	15 %	
B. — Percentage of fractures according to the appearance of the fracture :			
a) Fresh and clean fracture through the whole of the rail section :			
1. With silvery oval mark 2. Without silvery oval mark	38 %	43 %	The attention of the permanent way staff is not yet sufficiently directed to noticing fractures with silvery oval marks.
b) Fractures, part of which are old and much rusted, extending to the outer face of the foot or head of the rail :			
1. Rusted part in the foot.	57 %	57 %	
2. Rusted part in the head	2 %	...	
c) Fractures with much rusted parts not extending to the outer face of the foot or head of the rail	3 %	...	
d) Number of pieces into which the rail is broken : two	90 %	100 %	
— — — — three	10 %	...	

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails:															*Maximum axle load.*
	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
COLONIES.								Miles.			Miles.			Miles.		
Dutch India State Railways. (Java, Sumatra and Celebes). *Light rails :* of a weight less than 42.5 kgr. per metre or 85 lb. per yard.																
Number and percentage of fractures in the portion of the rail covered by the fish plates.	...	412	...	...	316	...	...	449	...	...	254	...	4 (1)	1 325	2	...
Number and percentage of fractures clear of the fish plates.	...	...	...	...	...	...	...	...	...	...	...		24 (2)		12	...
Number and percentage of :																
a) Clean and fresh breaks through the whole of the rail section . . .	...	...	...	...	...	...	...	...		...	...	...	9 (3)	...	...	...
b) Breaks with old part extending to the outer surface of the :																
1. Foot of the rail . .	...	...	...	...	...	...	...	...	...	...	...	...	9 (3)			...
2. Head of the rail . .	...	...	...	...	...	...	...	...	...	...	...	...	4 (1)	..	...	...
c) Breaks with old part not extending to the outer surface of the rail	..	...	...	...	...	...	...	..	...	...	...	...	6 (4)	...	...	

d) Number of pieces of the broken rail : 2. (In two cases the fracture was not complete).

Number of train-miles : 14 196 016.
Total number of fractures : 28.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 12.25.

(1) 14.4 %. — (2) 85.6 %. — (3) 32.2 %. — (4) 21.2 %.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	5	16	17
Dutch India Railway Company.														Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	1 (1)	146	4	13.5

Number of train-miles : 2 657 536.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 2.

Fractures at the joint : none; outside the joint : 1.
No silvery oval mark.
The break was old in the web and in the foot of the rail, and new in the head.
Broken in two pieces.

(1) 33.5 kgr. (67.60 lb. per yard) rail.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
POLAND. State Railways. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre (85 lb. per yard).	40	1 012	25	18	290	39	173	2 105	51	185	2 763	42	1164	7 061	102	18
Medium rails : of 42.5 to 52.5 kgr. per m. (85 to 105 lb. per yard).	...	...	...	...	72	...	3	287	6	...	298	...	2	99	13	18
Total . . .	40	1 012	25	18	362	31	176	2 392	46	185	3 061	38	1166	7 160	101	...

(*) Year 1926.

Number of train-miles : 62 760 000.
Total number of fractures : 1 585.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 157.

As regards supplementary figures relating to the circumstances under which the fractures occurred, the Ministry of communications can only give approximate figures and for light rails only as follows :

A. — Percentage of fractures in the joint : 45 % and clear of the joint : 55 %.

B. — *a)* Percentage of clean new fractures through the full section of the rail (silvery oval marks not having been recorded) : 41 %

b) 1. Percentage of fractures, part of which is old and much rusted, extending to the outer surface of the rail. .

b) 2. Percentage of fractures with rusted part in the head of the rail : 14 %.

c) Percentage of fractures not extending to the outer surface of the foot or the head : 15 %.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PORTUGAL. Portuguese Railway Company.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre (or 85 lb. per yard).	1	156.029	3.9	...	...	...	...	...	...	...	...	...	933	1 161.420	499.1	...
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	0	65.833	...	0	32.389	...	1	38.712	16	0	29.221	21.2	4	24.482	101.5	17.33
Total. . .	1	221.862	...	...	32.389	...	1	38.712	...	...	29.221	...	937	1 185.902	...	...

Number of train-miles : 6 265.643.
Total number of fractures : 939.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 931.2.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ROUMANIA. State Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	23	6 720	2.13	24	6 720	2.22	70	6 720	6.47	110	6 720	10.17	1838	6 720	169.96	17.7
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard.)	16(1)	130	76.55	1	130	4.78	1	130	4.78	1	130	4.78	...	130	...	19.7
Total. . .	39	6 850	3.53	25	6 850	2.26	71	6 850	6.44	111	6 850	10.07	1838	6 850	166.75	...

Number of train-miles : 33 714 353.
Total number of fractures : 2 426.
Total of single track : 6 850 miles.
Fractures at the joint : 699.
Fractures outside the joint : 1 727.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 447.

To the table above, 342 fractures of rails of unknown age must be added. The statistical returns do not give the lengths of single track line of each class of rail grouped according to age. In the same way it is not possible to classify the fractures according to the defects in the metal revealed by the appearance of the section, etc., as laid down by the London Congress.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
KINGDOM OF SERBIA, CROATIA AND SLOVENIA. State Railways. (Standard gauge lines.)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	25	228	68	7	702	6	41	378	67	22	359	38	1248	3 465	224	15.7
Medium rails : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	...	7	...	3	8	230	3	113	16	24	162	92	13	159	51	...
Total. . .	25	235	68	10	710	9	44	491	56	46	521	55	1261	3 624	216	...

Number of train-miles : 24 597 585.
Total number of fractures : 1 386.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 350

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SWEDEN. State Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	17	5 147	...	20	5 147	...	10	5 147	...	29	5 147	...	118	5 147	...	...
Medium rails : of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	15	247	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total. . .	...	5 394	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Total number of fractures : 209.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Gefle-Dala Railway. (*)		Miles.			Miles.			Miles.						Miles.		English tons.
Light rails:																
of a weight less than 42.5 kgr. per metre (or 85 lb. per yard). 1925	...		...	...		...	3		41.7	...	...	...	3		9.3	
1926	...	10.6	...	...	80.8	...	...	72	...	...	...	...	1	200.1	3.1	12.3
1927	...		...	...		...	2		27.8	...	...	...	2		6 2	
Medium rails:																
of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard.) 1925	1	9.9	62.5	2	70.8	17.6	...	216.2	...	...	...	...	...	...	...	
1926	1	9.9	62.5	1	70.8	8.8	1	216.2	2.9	...	...	...	...	...	...	17.0
1927	...	19.9	...	2	70.8	17.6	...	206.3	...	...	...	...	...	...	...	

(*) Years 1925 to 1927.

Number of train-miles : 2 796 220.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 13.3.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Göteborg-Borås and Borås-Alfvesta Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails:																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	7.5 (1)	...	...	15.5 (1)	...	...	26.1 (1)	...	...	1.2 (1)	...	...	111.8 (2)	...	13.8

Number of train-miles : 682 149.

No broken rails on this system in 1927.

Halmstad-Nässjö Railway. No broken rails on this system in 1927. — Number of train-miles : 847 660.

(1) Weight : 41.18 kgr. per m. (83.01 lb. per yard). — (2) Weight : 32 kgr. per m. (64.51 lb. per yard).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Helsingborg-Hessleholm Railway.																English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	4	...	33.8	13.8

Number of train-miles : 384 685.
Total number of fractures : 4 (all occurring in stations).

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 64.6121

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Kalmar-Nya Railway.														Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	1	121	...	16.2

Number of train-miles : 444 042.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 14.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Karlstad-Munkfors-Nordmarks-Klarelfvens-Filipstads-Nora-Bergslagen Railway.														Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	..	...	...	...	...	...	...	...	...	8	106.0	47	4.65

Number of train-miles : 392 182.

Total number of fractures : 8.

Nässjö-Oskarshamn Railway.	No broken rails on this system in 1927.
Nora-Bergslagen Railway.	No fractured rails in 1927. Number of train-miles : 253 812.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Norra-Östergötland Railway.														Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	9	54.7	102	8.4

Number of train-miles : 284 497.
Total number of fractures : 9

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 192.6.

Norsholm-Westervik Hultsfred Railway. No fractured rails in 1927.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Oxelösund-Flen-Westmanland Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per m. or 85 lb. per yard.	1	186	2.85	2	186	6.7	7	186	20.8	21	186	62.4	52	186	154	15.2

Number of train-miles : 29 564 747.
Total number of fractures : 83.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 17.4.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Stockholm-Roslagens Railway.														Miles.		English tons.
Light rails : of 22.8 kgr. per metre (45.96 lb. per yard.)	...	...	...	...	...	...	...	...	...	...	...	...	4	62	40	11.8

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Stockholm-Västerås Bergslagen Railway					Miles.									Miles.		
Light rails ; of 40.5 kgr. per metre (81.64 lb. per yard).	...	...	...	...	...	...	...	...	...	...	...	...	4	268	9.3	...
Medium rails : of 43.5 kgr. per metre (87.69 lb. per yard).	...	...	...	0	29.8	0	...	...	...	...	...	...	...	...	...	...

Number of train-miles : 1 222 790.
Total number of fractures : 4.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 20.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Västergötland-Göteborg Railway.																English tons.
Light rails, of a weight less than 42.5 kgr. per metre or 85 lb. per yard	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8.7

Number of train-miles : 808 771.
Total number of fractures : 0.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 0.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SWITZERLAND. **Federal Railways.**																English tons.
Total: 1 679 miles. *Light rails*: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	0	...	...	1	...	...	6	...	...	4	...	...	159	...	...	20.1
Total: 1 876 miles. *Medium rails*: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	4	...	...	10	...	...	33	...	...	23	...	...	55	...	...	20.1
Total: 3 555 miles.	4	...	...	11	...	...	39	...	...	27	...	...	214	...	...	...

Number of train-miles: 21 651 686.
Total number of fractures: 294.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles: 84.3.

Note. — It is not possible to supply this information separately according to the age of the rails.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Berne Alpine Railways. **Berne-Loetschberg-Simplon.** *a*) Loetschberg Line.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	4.498	...	...	0.947	...	7	42.128	103	...	1.243	...	...	19.211	...	19.7
Medium rails: of 42.5 to 52.5 kgr. per metre (85 to 105 lb. per yard).	11	5.397	1266	...	2.141	...	4	12.551	198	...	...	...	...	...	...	19.7
Total. . .	11	9.895	690	...	3.091	...	11	54.679	125	...	1.243	...	...	19.211	...	...

Number of train-miles: 842 360.

Number of fractures per 10 000 000 train-kilometres or

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
b) **Erlenbach-Zweisimmen Line.**		Miles.												Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	1.305	...	...	...	...	...	...	...	...	...	...	...	13.467	...	12.51

Number of train-miles : 82 324.
Total number of fractures : 0.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
c) **Spiez-Erlenbach Line.**		Miles.			Miles.									Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	1.678	...	...	0.216	...	...	...	...	...	...	...	...	4.655	...	12.51

Number of train-miles : 50 503.
Total number of fractures : 0.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 0.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
d) **Bern-Schwarzenburg Line.**		Miles.			Miles.											English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	1.212	...	...	1.212	...	...	...	...	...	...	...	...	9.410	...	12.51

Number of train-miles : 85 526.
Total number of fractures : 0.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 0.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
e) **Gürbethal Line.**		Miles.			Miles.									Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	1.864	...	...	0.342	...	...	0.410	...	...	...	...	2	16.501	75.3	12.51

Number of train-miles : 190 134.
Total number of fractures : 2.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 65.36.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
f) **Berne-Neuenburg Line. (Direct line.)**		Miles.												Miles.		English tons.
Light rails: of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	0.760	...	...	...	...	...	0.506	...	...	...	...	1	23.209	26.7	17.6

Number of train-miles : 224 053.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 27.73.

Lausanne-Ouchy Railway.	No broken rails in 1927.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Rhætian Railway.														Miles.		
Light rails; of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	...	...	...	...	...	...	2 (IIBb) 1		...	...	...	...	1 (IIAb)	...	...	...
Total.	...	...	...	...	...	...	3	...	...	...	...	...	1	...	...	...

Number of train-miles : 236 621.

Total number of fractures : 4.

To this classification we would add that in two cases old fissures existed in the foot and the web which **resulted** in the fracture of the head of the rail. In another case, only part of the head broke away and in the fourth case, in rails having been in service more than 20 years in the track, the head broke away at the fishplate holes for a length of 12 inches. In short, we have had 2 transverse and 2 longitudinal fractures of rails.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails:															*Maximum axle load*
	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CZECHOSLOVAKIA.		Miles.			Miles.			Miles.			Miles.			Miles.		
State Railways.																
Light rails:																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	6	524.6	7.1	18	442.4	25.3	5	968.7	35.9	53	1 095.4	30.1	609	4 819.3	78.5	...
Medium rails:																
of 42.5 to 52.5 kgr. par metre (85 to 105 lb. per yard).	4	634.1	3.9	4	192.1	12.9	9	392.2	14.3	10	419.1	13.8	3	270.5	6.7	...
Total. . .	10	1 158.7	5.4	22	634.5	21.5	65	1 360.9	29.7	63	1 544.5	25.3	612	5 097.8	74.6	...

Number of train-miles : 66 317 811.
Total number of fractures : 772.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 72.3.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	
URUGUAY. North Western of Uruguay Railway.	No fractures of rails in 1927.

MISCELLANEOUS INFORMATION

[624. (0 & 669 .1]

1. — The use of silicon steel in the construction of railway bridges.

The German review *Die Bautechnik*, No. 22 of the 25 May 1928, contains an interesting article by Mr. Schaper on a voyage of investigation in Switzerland. He gives particulars of a single line railway bridge built over the Aar canal, at Brügg, the structure of which is in silicon steel. (Si Stahl.) The main trellis-work girders are built in two bays each of 55 metres (180 ft. 5 1/2 in.) span. The total weight of steel, is 300 tons.

The silicon steel was supplied by the Wendel steel works in Alsace-Lorraine and by the Burbach steel works. The metal is uniform and of excellent quality. It met, in every respect, the requirements of the German State Railways' specification for this class of material.

It should be noted that certain large flats 20 mm. (0.787 inch) thick, gave an apparent elastic limit not less than 36.2 kgr. per mm^2 (22.98 English tons per square inch) with a breaking strength of 55.5 kgr. per mm^2 (35.24 English tons per square inch).

As regards working the material, *i. e.*, drilling, shearing, and planing, it was found that the silicon steel did not need any greater power than that taken to work ordinary steel.

The workmen even stated this steel was easier to drill than the ordinary steel.

Riveting also, did not call for any special precautions.

Joints difficult to get at, and which might have caused difficulties in maintenance, were welded. It was found that electric welding could be done quite normally.

This silicon steel was the first supplied by the Wendel steel works. This shows there is no special difficulty in making it and that it can be used generally, in structures above a certain size.

There is a tendency for its use to become more general.

The U. S. S. R. intend to prescribe the use of this new material in the near future in the construction of several important rail and road bridges, on the Dnieper.

The Chinese railways also have copied their example and the Americans are now also beginning to recognize that silicon steel is the best material to use in the construction of large bridges.

R. D.

[624 (0 & 669 .1]

2. — High tonnage steel in modern bridges.

The American review *Engineering News-Record* in its number of the 26 January 1928 devotes an article, over the signature of Mr. L. S. Moisseff, to the use of high tonnage steel in the construction of modern bridges.

In up to date construction work, a bridge has ceased to be an inert mass, but has come to be considered as a system of forces in equilibrium materialised in stone, wood, or metal. The tendency, continues to extend to make the materials work under the highest possible stresses and to increase this maximum by improving the materials. This tendency is especially marked (as it is also more necessary) in large structures in which the dead weight of the structure is particularly important in comparison with the useful live loads (for example, in the Hudson bridge, the proportion of the useful load to the dead weight is as 1 to 5).

In America in recent years, different special steels have been used and some particulars will be given of them below.

Nickel steel. — This steel was first used in 1920 in the Queensboro bridge — New York City — for the eye bars. Its characteristics were :

Elastic limit : 48 000 lb. on bars 16 × 2 inches.

Breaking strength: 85 000 lb. with 9 % elongation on 18 feet and a reduction of area of 40 %.

6 000 tons of nickel steel out of a total weight of 53 000 tons were used.

In the Manhattan suspension bridge, the stiffening trusses were also made of nickel steel.

In the Quebec bridge 16 300 tons of nickel steel were used, out of a total of 66 500 tons.

More recently, the stiffening trusses of the bridge over the Delaware at Philadelphia were made of nickel steel.

In 1915 use was made in the construction of the Harahan bridge at Memphis (Tennessee) of a steel known as « Mayari Steel » — a nickel chrome steel, made from a special ore from Cuba.

The tests gave an elastic limit of 55 000 lb. per square inch, and a breaking strength of 85 000 to 100 000 lb.

Silicon steel. — This steel was used for the first time in 1915 in the construction of the Metropolis bridge over the Ohio. The characteristics specified were :

Elastic limit : 45 000 lb.;
Breaking strength : 80 000 to 100 000 lb.;
Elongation : 17 %;
Reduction of area : 35 %.

Silicon steel was again used in the Cincinnati bridge in 1917 and more recently still in bridges over the Delaware and the Carquinez.

The increase in price of this steel over ordinary steel does not exceed one cent per pound.

Special carbon steel. — Two kinds of special carbon steels are in use in America having the following characteristics :

	1	2
Breaking strength, lb. per square inch	105 000	80 000
Apparent elastic limit, lb. per square inch	73 000	50 000
Elongation in 18 feet, per cent. .	5	8

Quality No. 2 has been used recently in the construction of the suspension bridges of the Carquinez Straits and of Florianopolis.

Steel wire. — Since White and Hazzard in America and Seguin in France built the first cable suspension bridges, steel wire has been used for this purpose on a large scale. Ever since the Brooklyn bridge was built, endeavours have been made to increase its elastic limit and its breaking strength.

The table below shows the progress made in this direction.

Brooklyn	(1880) :	160 000 lb. per square inch.		
Williamsburg	(1900) :	200 000 lb.	—	—
Manhattan	(1906) :	210 000 lb.	—	—
Delaware	(1923) :	215 000 lb.	—	—
Hudson	(1927) :	220 000 lb.	—	—

Up to the present no definite knowledge as to whether these steels will retain their values in service, is available.

Rivet steel. — Nickel steel has also been used for rivets with favourable results.

R. D.

NEW BOOKS AND PUBLICATIONS

[624 .51 (01 (.73)]

FOWLER (Charles Evan), Consulting Engineer. — **The Detroit Windsor Bridge over the Detroit River.** — A pamphlet (8 1/2 × 11 inches) of 26 pages with many figures. — 1928. New York City, 25, Church Street. (Price : 1 dollar.)

The interesting details given below have been taken from a pamphlet written by Mr. Charles Evan Fowler, Consulting Engineer, of New York, on the Detroit Suspension Bridge.

Clear height to be given by the bridge. — This height should be great enough to allow ocean going boats coming up the St. Lawrence to pass under.

In the case of one of the steamers considered, the *Montauk* of 10 000 tons, the maximum height of the mast is 112 feet.

The American Radio Company consider that when equipping ordinary ships with 2-kw. wireless sets, 50-foot masts are needed : with 5-kw. sets, the maximum height required is 100 feet.

Opening of the suspended span : 1 850 feet.

Comparison of the projected designs.

Various proposed designs were compared : wire cable or eye bar suspension bridges, cantilever bridges, and arch bridges of the Hellgate bridge type.

In the end, *the wire cable suspension bridge* was selected as being easier to build and cheaper.

Decking. — Two decks, an upper and a lower, were provided. The *lower* deck carries four standard gauge lines of railway operated by electric traction. The *upper* deck carries two tramway tracks in the centre and two 28-foot roadways, one on each side accommodating six lanes of automobile traffic. Two outside footpaths for pedestrians have also been provided. The width of 28 feet is considered ample to provide for three lanes of automobile traffic.

Live load capacity.

Congested live load.

Footpaths.	2 of 7 feet at 100 lb. per square foot =	1 400 lb.
Roadways.	2 of 28 — at 100 lb. — — =	5 600 lb.
Tramways	2 tracks at 2 500 lb. per lineal foot . . =	5 000 lb.
Railways	4 — at 6 000 lb. — — . . =	24 000 lb
	Total per *lineal foot* . .	36 000 lb.

Normal live load.

Footpaths.	2 of 7 feet at 50 lb. per square foot =	700 lb.
Roadways.	2 of 28 — at 50 lb. — — =	2 800 lb.
Tramways	2 tracks at 1 000 lb. per lineal foot . . =	2 000 lb.
Railways	4 — at 75 % of 6 000 lb. . . . . . . =	18 000 lb.
	Total per *lineal foot*. . .	23 500 lb.

In fact, the maximum loads which may be experienced can be considered as being the following : 50 lb. per square foot at most for the foot paths.

The Williamsburg bridge shows that the loading by automobiles rarely exceeds 42 lb. per square foot on very long spans. The load of tramways per lineal foot is very unlikely to exceed 100 lb. and for railways the load of 6 000 lb. given is undoubtedly much higher than any actual load.

In calculating the decks the live loads taken into account are given below, care being taken to take into account an impact co-efficient calculated for a speed of 20 miles an hour.

Footpaths : 100 lb. per square foot;
Roadways : 20-t. lorry + 25 % impact;
Tramways : 50-t. coach + $\frac{150}{L + 300}$ impact;
Railways : Type E 60 train + $\frac{150}{L+300}$ impact.

Obviously temperature, wind, etc. allowances have to be added.

Unit stresses to be permitted.

1° Dead load + average live load + temperature or dead load + temperature + wind.

Tension :

Cable wire : 85 000 lb. per square inch;
Suspender wire : 40 000 lb. per square inch;
Alloy steel : 30 000 lb. per square inch;
Structural steel : 20 000 per square inch.

Compression :

Alloy steel : $30\,000 - 120\frac{l}{r}$;
Structural steel : $20\,000 - 80\frac{l}{r}$.

2. Dead load + congested live load + temperature or dead load + normal live load + temperature + wind.

Tension :

Cable wire : 100 000 lb. per square inch;
Suspender wire : 50 000 lb. per square inch;
Alloy steel : 45 000 lb. per square inch;
Structural steel : 20 000 lb. per square inch.

Compression :

Alloy steel : $45\,000 - 150\frac{l}{r}$;

Structural steel : $20\,000 - 80\frac{l}{r}$.

Unit stress tower posts :

Alloy steel in compression : $35\,000 - 140\frac{l}{r}$.

Steel specifications.

Ordinary grades of steel could not be employed for a structure of such size, and investigations were made in America and elsewhere for special grades of steel suitable for the purpose.

The steel wire used in the Manhattan bridge had an ultimate strength of 215 000 lb. per square inch and an elastic limit of 68 % thereof. For the Detroit bridge a wire of 230 000 lb. ultimate strength with an elastic limit exceeding 75 % of this value was needed.

The chemical composition of the wire used in the Manhattan, Williamsburg, Philadelphia and Detroit bridges and those proposed by the author are given in the following table.

	C	Mn	Si	P	S	Cu
Williamsburg	0.85	0.50	0.10	0.04	0.03	0.02
Manhattan	0.85	0.55	0.20	0.04	0.035	0.02
Philadelphia	0.85	0.60	0.24	0.04	0.04	0.04
Detroit	0.85	0.60	0.24	0.04	0.04	0.04
Fowler	0.85	0.60	0.25	0.045	0.05	0.03

The minimum elongation required for the Manhattan bridge was 2 % on 12 inches before galvanising and 4 % after; for the Williamsburg, 2 1/2 % on 5 inches and 3 % on 8 inches; for the Philadelphia, 4 % on 10 inches; and the Detroit-Windsor and Fowler, 4 % on 10 inches.

The wire submitted by an English firm of the chemical composition specified for the Detroit bridge, would allow a working stress of 130 000 lb. per square inch as it showed the following results on testing, in lb. per square inch :

Test.	Area.	Yield point.	Ultimate strength.	Elongation.	Reduction of area.
S 572	0.0281	190 400	231 392	4.2	45.2
S 573	0.0281	192 192	229 600	5	45.2

The various long span bridges recently built in America have used either nickel steel, or else silicon steel, this latter being only ordinary carbon steel with the addition of silicon. The composition of the silicon steel was C 40, Mn 1.00, Si 0.45, P 0.04, S 0.05.

The actual mechanical tests of this steel gave an elastic limit of close to 30 000 lb. on an average so that only a slight change is necessary to produce an alloy silicon steel with the required elastic limit of 55 000 lb. per square inch.

The breaking strength by the addition of silicon can be calculated either by Hadfield's formula (*Journal of the Iron and Steel Institute*) by Yensen's formula (*Bulletin No. 83, University of Illinois*) or by Carnegie's formula.

Breaking strength :

$$39\,000 + 950\ C + 1\,050\ P + 85\ Mn + 140\ Si.$$

Using this formula on a steel described by Hibbard in « Alloy Steel » which gave an ultimate strength of 113 760 lb. per square inch and an elastic limit of 74 000 for a chemical composition of

C 0.40, Mn 0.45, Si 1.40, P 0.04, S 0.05,

we obtain a close check of 112 225 lb. per square inch.

Applying this formula to a steel with a chemical composition, as recommended to the author by an eminent metallurgist

C 0.60, Mn 1.00, Si 0.45, P 0.04, S 0.05,

we get an ultimate strength of 115 000 lb. per square inch and an elastic limit of 57 500, characteristic of a high carbon silicon steel.

A silicon steel of the composition recommended by the author C 0.50, Mn 1.00, Si 1.00, P 0.04, S 0.05 would give a breaking strength of 113 200 lb. per square inch and at only 50 % an elastic limit of 56 600 lb. We may therefore conclude that a steel having a composition of C. 0.55, Mn 1.00, Si 0.55, P. 0.04 S 0.05 giving an ultimate strength of 110 650 lb. per square inch and 55 000 lb. elastic limit would be sufficient for the present bridge.

Tower design.

After comparison with the fixed towers of the Manhattan bridge, it was decided to use hinged towers. The stresses after calculation were checked from a paper model in accordance with Beggs' method.

The base and hinge castings are of cast steel, the largest section weighing less than 20 tons, each base covering an area of 22 × 25 feet producing a pressure of only 510 lb. per square inch on

the masonry. The hinge rollers are formed of 16 segmental rollers 24 inches in diameter.

Cable design.

The fundamental idea was to give the cables the same diametre : 21 3/4 inches as those of the Manhattan cables which is believed to be the maximum practical size and would reduce the time required for stringing the cables by half.

The sag adopted : 1/10th of the span;
Diametre of the galvanised wires : 0.192 inches as used for the Manhattan and Williamsburg bridges.

The eight cables have nineteen strands each, the four upper cables being 21 inches in diametre with 420 wires per strand and 7 980 wires per cable. The two inside lower cables are of the same size but the two outside are 18 inches in diametre with 300 wires to each strand and 5 700 wires to a cable.

The average variation in the sag of the cables due to temperature will be 2.97 feet and due to full live load 8.84 feet.

Stiffening trusses.

The bridge having been built with a single deck (the railway deck having been added subsequently) the stiffening trusses having no dead load stresses they will also be strengthened subsequently to take their full proportion of live load stresses of the deck carrying the standard gauge railways.

R. D.

[621 .51 (.44)]

LA HOUILLE BLANCHE. — **L'Électrification du Chemin de fer du Midi** et l'essor économique de la région du Sud-Ouest. (WATER POWER. — **The electrification of the Midi Railway** and the economic development of the South-Western District). — Special publicity number, published by *Le Sud-Ouest Économique.* — One volume 8° (10 1/2 × 9 inches) of 368 pages with many illustrations. — 1928. Bordeaux, Le Sud-Ouest économique, 6, place Saint-Christoly. — Price : 25 francs.

The Midi Railway is the French railway, on which the work of electrification is the most advanced. It is also the one on which the plans which have been prepared provide for the greatest proportion of electrified line. These circumstances are the result of its geographical position. As its distinguished director, Mr. Paul, writes, the railway has developed all along the chain of the Pyrenees over a district 180 to 200 km. (110 to 125 miles) in width and is therefore particularly well placed at all points, having regard to the possibilities of carrying current to long distance, to get supplies produced by power stations generating current from the water falls in the Pyrenees.

The electrification will exercise a large influence on the economic position of the whole of the South. In addition to the benefits the Company will get from it and the greater facilities given the public, it must be considered that the plant for generating and transporting electric energy has not only taken the railway requirements into account, but includes a wide distribution system, making electricity available for other users. The undertaking having been designed on lines whereby electrical energy will be widely distributed, cannot fail to help the development of existing industries and even to induce the introduction of new ones. The very carrying out of the work of all kinds involved in the conversion to electric traction of so many lines, has caused a new activity in the

areas concerned. It is consequently understandable that the *Sud-Ouest Economique* should have thought of making the *Electrification of the Midi Railway* the subject of a special number. This number is well presented and fully illustrated, and is also instructive reading for an engineer.

The number opens with an interview with Mr. André Tardieu, in which the Minister for Public Works broadly outlines the programme of electrification of the French railways and shows the essential advantages thereof.

Mr. Paul then, in a noteworthy sketch, points out the magnitude of the work undertaken by the Midi Company, gives particulars of the results already obtained, and indicates what remains to be done to complete the work and to obtain the fruit therefrom.

The various plant is described by the Engineers of the Company responsible for the design and the carrying out of the work in a series of very interesting notes in which all the essential technical data are to be found. To quote them in order, they are : *The large power stations of the Midi Railway Company*, by Mr. Godard, Engineer in chief of the Bridges and Roads Service, Engineer in chief for the construction of new lines and Hydro-electric power stations; *The Distribution of Electric Energy*, by Mr. A. Bachellery, Chief Engineer of Rolling Stock and Locomotive Operation; *Transformers and Sub Stations*, by Mr. J. Villeneuve, Assistant Chief Engineer for the technical services in the Chief Mechanical Engineer's department; *The Rolling Stock*, by Mr. P. Leboucher, Chief Engineer, Technical Services in the Chief Mechanical Engineer's department.

The first part also contains a note by Mr. Garan, Engineer in Chief of the Bridges and Roads Service, Chief Engineer for the Construction of new lines, who discusses the question of the Transpyrenean lines, a note by Mr. Henri Martin, who describes the most noteworthy works on the Aix-les-Thermes to Latour-de-Carol line, and a series of notices showing the development and the field of activity of the great industrial undertakings who have taken part in the Electrification of the Midi Railway.

In the second part, the reader will find information on the local industries which are expected to benefit by having electric energy at their disposal.

The third part brings out the wonderful future for the tourist industry in the South and calls attention to the marvels of nature in the region of the Pyrenees. Amongst these we will call attention to a note on *the Role of the Railway Companies and in particular of that of the Midi, in the efforts of France to encourage touring*, by Mr. J. Arnouil, General Inspector of Touring services of the Company.

E. M.

SACHS (KARL), Doctor of Engineering, Engineer of the Brown Boveri Co., Baden (Switzerland). — **Elektrische Vollbahn-lokomotiven (Railway Electric Locomotives)**. — One volume 4o (8 × 10 1/2 inches) of 461 pages with 448 illustrations in the text and 22 folded plates. — 1928, Julius Springer, Publisher, 23-24 Linkstrasse, Berlin, W. 9. — Price bound : 84 Reichsmark.

Those interested in electric traction frequently find in the technical press articles on projected schemes or schemes in course of execution in various countries.

The reading of these articles, which are sometimes general in their outline, but at the same time deal with one subject only, however interesting they may be, is not of much value unless the reader has a general knowledge of the subject. For this reason a book dealing with elec-

tric traction in a methodical manner, even if rather didactic, cannot fail to be of great use both to practising engineers and to those who wish to study the subject and thereby obtain knowledge of it.

The subject being of course very wide, any book would gain in interest and usefulness if it limited itself to a well defined part of the subject. The object of this book is to explain the electric locomotive, which is the heart of the electrification of a railway.

However important the fixed plant, the power stations, the distribution mains, the transformer stations, the contact lines may be, an electric locomotive, which is an engine both mechanical and electrical and which has given rise to many complicated questions, still remains the essential problem.

In the introduction, the author compares the steam and electric locomotives as regards their tractive effort and power.

The book is divided into four chapters as follows :

1st: Traction power, and horse power;

2nd : Mechanical equipment (the vehicle);

3rd : The electric equipment;

4th : Description of locomotives that have been built.

In the first chapter the methods and formulæ by which the tractive effort and the power to be developed can be calculated are described. The author goes on to describe the method of tracing the curves showing the various factors to be considered during the running of the train. He has set them out for the principal systems of electric locomotives.

The object of the second chapter is the one that has caused the greatest difficulty and necessitated the most investigation. This problem is more a mechanical than an electric one whether it be either the building of the vehicle or devising a satisfactory arrangement of drive from the motors to the wheels. This latter can be done without the use of reduction gears, or with them, and the methods used again depend on the kind of current and the sort of motors used. The height of the motors has a great effect on the stability of the locomotive, and the theories developed for steam locomotives are applied in the book. The same may be said of the method of connecting the main frame to the trucks and bogies, and the motor bogies together, and as regards the inscription of the locomotive on curves. All these points are gone into in detail. This second chapter also contains a complete description of the brake gear both vacuum and compressed air.

The third chapter (electric equipment) includes four parts : continuous current locomotives, monophase locomotives, three phase locomotives, and locomotives on which the current is transformed.

This chapter is a complete descriptive and theoretical treatise on the machines and appliances to be found on an electric locomotive. Each part is preceded by an historical introduction which makes it possible to appreciate the extent of the work already done by inventors and builders alike.

The fourth chapter gives a detailed description, with folded plates at the end of the book, of fifteen electric locomotives in service in various countries of the world.

The many bibliographical references in the book are indexed in a table, giving them in alphabetical order, under their authors' names.

E. M.